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ABSTRACT

The Engineering Renewal and Growth (ERG) program at Colorado State University (CSU) was designed for continuing education of engineers. The program used videotapes and coordinated written materials to deliver instruction to the practicing engineer. Courses were leased to individual students or industries in which students worked. The courses were taken for continuing education units, not regular college credit, and instructional staff at CSU monitored student progress. Program evaluation was conducted by monitoring the program as a whole and assessing evidence on course effectiveness and quality. Issues related to students, faculty, the university, administration, and budgets were examined. Evaluation of the program showed that while the first year of ERG was modest, there was no financial barrier to growth. (CH)

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FINAL REPORT

STUDIES ON THE USE OF EXTRAMURAL VIDEOPUBLISHED MATERIALS IN CONTINUING EDUCATION

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August 1976

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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ABSTRACT

In its first year, the "Engineering Renewal and Growth," (ERG) program demonstrated that some of the continuing education needs of engineers can be met with videobased instruction managed by regular faculty. The videotapes and coordinated written materials used by the engineers at their job site and on their own schedule, were generally produced by other institutions. From the point of the adult learner, the fact that the courses in the ERG program were produced at other institutions than Colorado State University was not critical. Rather course content and cost were cited as important even though all participants were reimbursed by their employer for ERG fees. Completion rate for courses undertaken was excellent with all but 8 of 150 registrants finishing. The users were not interested in college credit, but felt a need for continuing education. Convenience and flexibility were cited as a major factor in the acceptance of the videobased ERG program, and many commented on the helpfulness of the coordinated study guides. The convenience observation reports the earlier finding of surveys in the graduate program, SURGE, but it should be noted that ERG served a significantly older clientele than SURGE.

Faculty attitude at Colorado State University to the extramural videopublished format of ERG is bipolar. That is, there are some supporters who regularly employ video, and even more antagonistic faculty who actively resist the use of video and very few who might be termed moderate users with neutral

opinions. The ERG faculty were generally drawn from the supportive user group and they judge the quality of videobased "package" courses in much the way they do textbooks. Content and technical quality are the most important factors. The use of a "package" course is viewed as not inconsistent with the role of the teacher who is viewed as a course planner, material selector, lecturer and motivator. The supportive and non-supportive faculty have representation among Colorado department heads and deans, but the general tone was more moderate at each pole.

Income fell short of expense in the first year of ERG. However, there appears to be no financial barrier to the rapid growth of the program to at least match the history of the companion graduate program, SURGE, and to eventual economic self-sufficiency. The limiting factor now appears to be the availability of videobased short course materials. The first year of ERG shows that suitable material is now being produced on a very limited basis by universities, a government research laboratory and industry.

This document is the final report for Grant No. HES 75-19854. The title of the grant is the same as of this report. The grant was made by the Division of Higher Education in Science, Materials and Instruction Development Section, Education Directorate, National Science Foundation.

Introduction

The purpose of the project was to evaluate a program at Colorado State University that was designed for continuing education of engineers. The program is called ERG, an acronym for "Engineering Renewal and Growth." The program used videotapes and coordinated written materials to deliver instruction to the practicing engineer at the job site. The College of Engineering at Colorado State University has a successful history of this kind of graduate education activity in its SURGE program, but had little experience with non-credit, short course materials produced by others.

The ERG program is unique from the SURGE program in several ways which are listed below.

1. The videopublished course materials were produced at a different institution than Colorado State University. Thus, the program provided an opportunity to study a general problem in the area of continuing education and videopublication. The problem is that such course materials may not be readily transportable and used beyond the situation in which they were produced.

2. The courses were leased to the individual student or industry in which the students worked.

3. The courses were not for college credit unless special arrangements were made to obtain credit.

4. Instructional staff at CSU were retained to monitor the work of the student. The relationship was not, however, so much teacher-student as adviser-monitor.

At the start of the project, twenty-four courses on twelve distinct topics or parts were offered in the ERG program. The twenty-four courses were all produced by the Center for Advanced Engineering Study at the Massachusetts Institute of Technology. Fourteen courses were added to the program during the year which were produced by four external organizations as well as CSU.

Material selection for the ERG program is accomplished in the following manner. The program director, Lionel Baldwin, screens videobased instructional courseware for production quality and adequacy of coordinated printed material. Almost without exception, this screening has to date limited the courseware selection to TV studio-produced tapes with specially written study guides which were produced for continuing education purposes with a national distribution objective. When a prospective course is identified from any source, a CSU faculty member who is expert in the subject matter is asked to review all printed material and view a sample videotape. Usually the appropriate faculty member is determined from a recommendation of the academic dean and department head. If the faculty member approves the course, he or she is asked to determine what academic credit (course level and number of semester credits), if any, would be allowed if a user petitions for credit by

examination. A program announcement is also prepared by the faculty. All approved courseware is then obtained for use in the ERG program through a contractual negotiation with the program director at CSU working through the appropriate official of the producing institution. In most instances, the latter proved to be quite lengthy, because the agreement with CSU was the first such contract of its type prepared by the producer (and for that matter, CSU was inexperienced, too!).

The ERG program provides CSU instructional services under the direction of regular faculty to fully employed engineers at their place of work on their schedule. In order to be cost effective as well as convenient, the instruction is based on videopublished lecture-demonstrations with coordinated printed materials. The instructional objectives are summarized by the CSU faculty member in charge of the course and these were published in an attractive brochure (see Appendix A). These were distributed to the training officers and where possible the engineering managers of industries in the geographic area. The industries and government facilities were also visited by a staff member from CSU. The program objectives and costs were explained by the brochure contents and the staff member's visit.

When an individual or an industry decided to take one or more courses in the program, the following procedures were used. The course materials were ordered from theproducer, and the instructional staff member at CSU was notified of the enrollment. The course materials were sent by the Office of

Educational Media at CSU to the students on a scheduled basis specified by them. The complete set of videotapes was generally not sent. Instead new materials were sent out about every two weeks, and the students returned the materials as they completed them. This procedure permitted closer monitoring of the students' progress than if the complete course were sent out at one time. Also the procedure permitted the use of the materials by several students if they were not at the same point in the course.

The basic enrollment costs for the student covered the lease costs of the course and the awarding of the appropriate number of Continuing Education Units (CEU) upon completion of the course. The CEU procedure provided a way to certify course completion. This was important for those adult learners who work in an industry that has a policy of reimbursing educational costs to an employee upon completion of an educational activity.

Ultimately, each industry which used ERG courses agreed to reimburse their employees through an adaptation of their tuition-refund, fringe benefit program. But the decision was not easily reached at several locations. Discussion often centered on whether examinations and grades were essential for tuition refund. In several locations, the CSU faculty member in charge of the course was asked to administer an informal quiz and to provide assurance that the course material had been learned (to some undefined extent, but similar to the pass-fail grading now popular in some colleges).

Students had the option to take the course for college credit. To do this, they had to pay an additional amount for tuition at CSU. Generally the students were also expected to submit work to the instructor for grading if they opted to take the course for credit.

The instructional staff at CSU was expected to monitor the students' progress, to provide assistance on request, and to certify completion of the course. Students did not submit material for evaluation unless they took the course for credit. The courses are basically self-contained and easily adaptable for individualized use but many faculty joined the ERG program director in urging small study groups meeting on a regular schedule of the students' chosing. Evaluation was necessary for the credit option to insure that the students' performance met the instructor's criteria for assigning grades and awarding credit.

The above material provides a brief description of the ERG program. The grant was for the evaluation of the program, and it should be emphasized that none of the grant money was used in the operation of the program. The remainder of this report will be of the evaluation work and results.

Evaluation Plan

The purpose of the evaluation study was to examine institutional and learner issues related to the use of imported videopublished materials in continuing education. Several different activities were conducted in the project to study the issues. The activities are listed below in the order that they are discussed later in the report.

1. General monitoring of the ERG program.
2. Evidence on course effectiveness/quality.
3. Issues related to the course user.
4. Issues related to faculty.
5. Issues related to the university.
6. Administrative and budgetary issues.

General Monitoring

The ERG program was organized during the summer of 1975 and was operational in September for the 75-76 school year. Twenty-four courses, all produced at MIT, were included in the program at the start. Fourteen courses were added during the year making a total of 38 courses in the program on July 15, 1976. Table 1 lists the courses. Each "Part" covers a self contained subject which varies in length from 6 lectures to 43 lectures. The videotaped lecture-demonstrations themselves vary from 10 minutes to 50 minutes in length and may require up to several hours of reading and problem solving to master the material of a single lecture (if that is the student goal).

The courses, therefore, vary greatly in length. For example, "Calculus Revisited" consists of three parts, each of which can be taken separately, while "Probability" has one part and is taken in its entirety. The column headed by "Parts" in Table 1 indicates the number of parts in each course.

The course listing indicates that the program was started with a good variety of courses relevant to the continuing education of engineers. The course additions which occurred very late in the year provided for the continuing education needs

Table 1

List of Courses Available in ERG

	Course Title	Producing Institution	Parts	Individual Lectures
1.	Calculus Revisited	Massachusetts Institute of Technology (MIT)	3	84
2.	Economics	MIT	2	22
3.	An Introduction to Experimentation	MIT	1	14
4.	Friction, Wear, and Lubrication	MIT	1	12
5.	Probability	MIT	1	49
6.	Random Processes	MIT	1	47
7.	Artificial Intelligence	MIT	1	24
8.	Colloid & Surface Chemistry	MIT	4	53
9.	Digital Signal Processing	MIT	1	20
10.	Mechanics of Polymer Processing	MIT	3	32
11.	Nonlinear Vibrations	MIT	1	23
12.	Modern Control Theory	MIT	5	71
13.	Management of Technological Innovation	MIT	1	6
14.	Engineering Economy	Colorado State University (CSU	1	10
15.	Manufacturing Quality Control	CSU	1	10
16.	Network Analysis and Design in the Frequency Domain	CSU	2	20
17.	Time Management	Association for Continuing Education (ACE)	1	6
18.	Introduction to Calculus	ACE	1	19
19.	Personal Money Management	ACE	1	12
20.	Financial Planning for Retirement	ACE	1	12
21.	Digital Sub-Systems	Texas Instruments (TI)	1	16
22.	Designing with Microprocessors	TI	1	16
23.	Semiconductor Memories	TI	1	11
24.	Fundamentals of Vacuum Technology	Purdue University	1	20
25.	Microprocessor Technology & Applications	Lawrence Livermore Labs	1	39
		TOTAL	38	

of an increasingly broad-based clinetele (see Appendix B), but the impact of the enlarged catalog is not yet reflected in the enrollment data.

The College of Engineering at Colorado State University has provided graduate education for engineers in industry since 1967 through a program called SURGE. This program had been very successful. Detailed descriptions, evaluations and economic studies of SURGE have been published (references 1 to 12).

The businesses, industries, and agencies that have participated in SURGE were the primary potential market for the ERG program. The fact that the SURGE network was well-established was definitely a plus factor for the ERG program. An institution starting a program like ERG should probably devote a considerable amount of lead time to market research and public relations to establish a receptive audience. This had been done at CSU with the SURGE program.

As indicated above, the ERG program was promoted to the SURGE network. There was not a strong campaign to promote ERG, however. An attractive brochure was distributed among the industries and agencies, and a staff member visited many of them. The staff member worked half-time for about four months on this assignment.

A sizable number of students did enroll in the ERG program during the first year. The enrollment data are summarized from September, 1975 to July, 1976 in Table 2. Had it been possible to devote more staff time and effort to making engineers aware of ERG, the enrollments would very likely have been considerably larger than they have been to date. However, like

SURGE, the learners have generally come in small groups (ranging from one to fourteen, with an average of 7.9 people at any given location and time).

Table 2

Enrollment in ERG Courses Up To July 1, 1976*

Course	Number Enrolled	Number of Industries
Artificial Intelligence	21	3
Calculus Revisited	7	2
Colloid Chemistry	25	3
Digital Signal Processing	30	3
Introduction to Experimentation	18	2
Modern Control Theory	11	1
Polymer Processing	14	1
Management of Technological Innovation	24	4
	150	

*During July 1976, there were 100 enrollments in seven courses from 14 industries.

A follow-up questionnaire was delivered in April to the students who had enrolled by January 31, 1976. Of the 90 questionnaires delivered, 63 were returned. Forty-four percent of those who responded had completed the course. Of those who had not yet completed, all but eight indicated that they would complete. Not included in these totals are six known drops in one course. The reasons for these drops are discussed in a later section of this report. One student opted to take the courses for college credit.

The materials distribution and financial aspects of ERG were handled by the Office of Educational Media at CSU. This

office has much experience with such an operation as it has done the same kinds of things with other programs, e.g., SURGE. Consequently, the logistical aspect of ERG functioned well. One problem that was not anticipated was encountered when some students dropped a course when they had received about one third of the materials. No clear policy had been established for such a situation. The money of this particular group of students was refunded because their expressed reason for dropping the course was "inappropriate course content." A policy needs to be established and clearly defined for the students in anticipation of such situations.

The record of completions is quite good. It should be recognized that the courses vary in length and also in difficulty. Consequently it is difficult to establish an average time for completion across all courses. Further experience with the courses will permit such an estimate for each course, which may be a useful bit of information for the potential enrollee.

It was mentioned earlier in this report that each course is monitored by an instructional staff member at Colorado State University. This person is paid a modest fee for this service.

The instructional staff members who had courses with enrollments were interviewed in April 1976. The purpose of the interview was to determine their reactions to the experience. They all reacted favorably as indicated by the fact that all indicated they would continue to participate as instructional staff in the ERG program. Perhaps one reason for the favorable

attitude is the fact that the monitoring work took little time and effort. The time requirements were from "little or none" to about one hour per week. They attributed this minimal time to their perception that the students are able to work independently and have little need for assistance. The courseware was generally designed to be self-sufficient. Three staff members indicated, however, that there should be more contact between the students and the instructors.

Most of the contact was at the beginning and the end of the course. Several staff members visited the industries and students when they were first enrolled. This visit served primarily as a sort of motivational procedure. The visit did not seem to stimulate further contact, however. Usually no further contact was made until the instructor was required to review the students' work and certify completion of the course.

The role of and fee structure for the instructional staff members needs to be studied more. The role at present is minimal and perhaps this is desirable. Certainly it is desirable that the students are willing and able to pursue the work independently. Considering the amount of time and effort required, however, the fee structure for the CSU faculty could perhaps be reduced somewhat.

Course Effectiveness/Quality

Each course in ERG is reviewed by appropriate CSU staff before it is adopted in the program. This review along with the fact that courses have a history of successful use by

the producing institution provides "before the fact" form of quality control.

Additional evidence on course effectiveness was obtained from a student questionnaire administered in April 1976, and from three small studies done during the year. It was reported earlier in this report that of the 63 students who returned the questionnaire, 44% had completed the course and 87% did complete or intended to complete the course. The high completion rate attests to course quality and effectiveness. Another indicator is the fact that 89% of the respondents indicated that they would take more courses in the ERG program.

The students were asked about suggestions for improvement in the courses. One course, "Introduction to Experimentation," was criticized for being too elementary. Another course, "Calculus Revisited," was criticized for being too abstract/theoretical. This course is discussed in more detail below.

Generally comments like "excellent," great course," "very relevant" typified the reactions of the students to the courses. The most common general criticisms were in terms of inadequacy of notes and textual materials and illustrations of practical application. What is practical for one person may be abstract for another. Courses in a program like ERG should have a wealth and variety of practical illustrations to optimize the likelihood that the student will encounter an application that is somewhat relevant to his situation.

Although not specifically course quality, the format of ERG has some relationship with perception of quality. Consequently the students were asked about their perceptions of

the format. The quality of the tapes was criticized in terms of picture and sound. This could be a function of the quality of equipment used by the student as well as the tape itself. Several students commented that the tapes should be shortened to no longer than one half hour each. Also several asked for more contact with the CSU instructor than they had. Two respondents expressed disappointment that the tapes for the course they studied were not in color. They had been told that the tapes were in color.

In the SURGE experience at CSU, it has been demonstrated that tape quality is not a critical issue. The students in SURGE were quite tolerant of less than high quality but adequate materials, because of the other advantages of the program. This also probably applies to ERG. Even so, every effort should be made to achieve as high technical quality as possible within the cost constraints of the program.

The following material presents more detailed information on the quality of three of the ERG courses.

Calculus Revisited

Six of the seven enrollees in Part I of Calculus Revisited dropped the course. They said the course was too abstract and theoretical and thus not relevant to their needs. The course has been used experimentally on the CSU campus in place of the regular calculus course. Its use in such a setting was quite successful. Perhaps this course is not so much a refresher as a basic course which suggests that it is more abstract than directly applicable to the professional engineer's situation.

Engineering Economy

The Engineering Economy course materials were tried out with a group of CSU students during the 75-76 school year. This course is in the ERG program and the course or parts of it is now being used by students in 12 locations. This usage is through a national distribution of videocourse which is operated at MIT. The course will be used in the fall of 1976 by the Association for Continuing Education at Stanford University.

Eighteen of the 72 students enrolled in the on-campus course volunteered to take the videopublished version of the course. They took the course independently, that is, they followed the procedures that would be used by an off-campus student. Three tests were taken in common by the 18 students in the videopublished course and the 54 in the regular class. The results are summarized in Table 4.

Table 3

Results of Three Tests in Engineering Economy

	Regular Class (N=54)		TV Class (N=18)			
Test	Mean	Standard Deviation	Mean	Standard Deviation	"t"	Probability
One	16.2	5.9	14.5	5.1	1.27	$p>.05$
Two	21.0	7.8	16.4	7.3	2.23	$p<.05$
Three	25.3	8.9	25.2	8.1	.06	$p>.05$

The regular class obtained higher means on the three tests than the video class, but the magnitude of the difference

reached the .05 level of significance only on the second test. It would appear the video class learned nearly as much as the regular class. The video class members spent less time on the course than the regular class and also were able to work on it at their convenience. Considering these trade-offs the videopublished version compares quite favorably with the regular class.

Artificial Intelligence

The "Artificial Intelligence" course was used on the CSU campus during the 74-75 school year. Eight of the nine students who took the course were interviewed in the fall of 1975. Their recall of the course was quite good, and they generally held favorable attitudes about the course. They offered some suggestions for improving the course. The suggestions included: 1) a structured textbook, 2) a better study guide, and 3) more problems and exercises. The academic department that used the course, computer science, was encouraged to continue using it.

Readability Study

Wells (reference 13) discussed the use of readability indices for evaluation of technical training materials. This idea seems good in that student reaction to training materials might be quite related to the level of difficulty of the materials. A readability study was done of two courses in the ERG catalog, "Calculus Revisited" and "Engineering Economy." These courses were selected because of the differing

reactions by students to them. The expectation was that "Calculus Revisited" would be more difficult than "Engineering Economy" in terms of readability.

The difficulty of the instructional material was determined by the use of the Dale-Chall Readability Formula (reference 14) as revised by Powers, Sumner, and Kearl (reference 15). The text of the video-taped lectures was transcribed and the transcribed text was analyzed by selecting samples of approximately 100 words from every third page. The study guides were evaluated by selecting samples of approximately 100 words from every tenth page. These procedures are consistent with the Dale-Chall procedures.

The results were not as expected. For both courses the readability for manual and tape transription was about at the tenth grade level. Furthermore, the readability levels of the "Calculus Revisited" tape transcription was significantly lower than for "Engineering Economy." The manual readability was essentially the same for the two courses.

"Calculus Revisited" was criticized for being too abstract and theoretical. The results of the study suggest, however, that the level of abstraction does not result from the verbal content being too difficult. It should be noted, however, that the procedures for determining readability ignore mathematical symbols and formulae. Consequently the perception of the course being abstract could be due in part to the mathematical language.

The evidence on course quality is generally favorable, which was expected considering the amount of effort that has

gone into the courses. The evidence does indicate, however, that there is at least one important consideration in building continuing education courses for professionals. The materials should be directly applicable to the situation of the professional and not too abstract and general.

Course User Issues

In this section of the report, two levels of course user are discussed, the industry and the student.

The Industry

Training officers in ten of the participating industries were interviewed regarding their perceptions of the ERG program. Most of the training officers had worked with the SURGE program and did not perceive the ERG program as anything very different. This is unfortunate from the point of view of CSU, because, SURGE is centered in the graduate credit offering of the university and ERG is intended to serve the non-credit, continuing education needs via short courses.

The engineers in the industries were informed about ERG by word of mouth and circulation of the brochure. Some enrolled in a course on the basis of this kind of information. More commonly, however, the engineers enrolled on the basis of the recommendation of a supervisor. The supervisor is aware of what knowledge and skills are or will be needed in a department. If a course in ERG seemed appropriate, he would recommend that those in his department take it. This procedure suggests that the professional working in a salaried position is not necessarily the best determiner of his continuing education needs.

The fact that the courses in the ERG program were produced at other institutions than CSU was not a critical issue. Course content and cost are the critical issues. The content should be relevant to present or future needs of the company and the cost should be reasonable. They seemed to feel that the role of CSU was useful in the sense that the university was performing a real service in finding and providing the courses. The training officers expressed a desire that the offerings in ERG be expanded. They also felt that the instructional component offered with the courses by CSU strengthened the program for them.

We questioned the officers about expansion of ERG to serve technicians and sub-professionals. They were of the opinion that the companies would provide their own training at this level and the ERG and SURGE should continue to be primarily concerned with continuing education of professionals.

It was interesting to observe the faith in continuing education that is held by the companies. They are not able to demonstrate (nor do they seem concerned) that continuing education investment has a direct payoff. They operate very much on the belief that continued education will ultimately benefit the individual and the company, but do not seek to "prove" it.

The general impression from the interviews is that the ERG program is serving the companies well. The operation of the program is efficient and it is providing another alternative in terms of course content and procedures for companies to provide for the continuing education of professionals.

Student Issues

Most of the information presented in this section is summary data from two questionnaires administered to ERG students who enrolled in courses by January 31, 1976. A pre-questionnaire was delivered to approximately 90 students who enrolled by that time soon after their enrolling. Seventy-six of these questionnaires were returned. The post questionnaire, mentioned earlier in this report, was delivered to the same students in April 1976. Sixty-three were returned.

Table 4 contains information on personal characteristics of those who enrolled in ERG.

Table 4

Personal Characteristics of ERG Students
(Percentages may not total to 100% because of rounding)

		N	%
1.	Age		
	Under 25	10	13
	26-30	20	26
	31-35	21	28
	36-40	14	18
	41-45	7	9
	Over 45	4	5
2.	Highest degree earned		
	No college degree	10	13
	Bachelor's degree	12	16
	Bachelor's plus hours	21	28
	Master's degree	3	11
	Master's plus hours	18	24
	Ph.D.	7	9
3.	How long have you worked with your present company?		
	Less than 6 months	4	5
	6 months to 1 year	4	5
	2 to 3 years	17	22
	4 to 6 years	18	24
	7 to 9 years	16	21
	10 years and over	17	22
4.	What is your present job?		
	All of the students were in engineering or technician type jobs, although in a few cases the job seemed to be as a manager or supervisor of others.		
5.	How long have you worked in your present job?		
	Less than 6 months	10	13
	6 months to 1 year	15	20
	2 to 3 years	24	32
	4 to 6 years	16	21
	7 to 10 years	9	12
	10 years and over	2	2
6.	How many SURGE courses have you taken, including those currently being taken?		
	None	26	34
	1 or 2	33	43
	More than 2	13	17
	No answer	4	5

The data indicate that the students may be typified as follows. They were baccaleaureate level engineers or technicians who were early in their career or at mid-career. Considering their age, they had relatively long tenure with their company, but less tenure in their present job. This would suggest they were an upwardly mobile group. The majority had experience with the SURGE program. The students were asked why they enrolled in the course and whether they intended to get college credit. The responses are summarized in Table 5.

Table 5

Expressed Reasons for Enrolling in ERG Course

1. Why are you enrolled in the course?
   (Sums to greater than 76 became of multiple reasons given by some)

a.	Application to Job	33
b.	Renewal and Growth	20
c.	Personal Improvement	15
d.	Interest	9
e.	Review	5
f.	To evaluate the course for future use	2

2. Do you intend to receive college credit for this course?

	N
Yes	8
Maybe	3
No	55

None of the respondents indicated that they were pressured into taking the course. This is interesting in view of the

perception of the training officers that supervisors often suggested to their subordinates that they take a course. If, in fact, the supervisor made such a decision there apparently was not undue pressure placed on the subordinate to enroll.

A few students did indicate they wanted to receive college credit for the course. One has followed through on this desire as of the end of the first year of ERG.

The students responded to six statements designed to elicit their attitudes toward continuing education and the medium of television. Their responses are summarized in Table 6.

Table 6

Student Attitudes Toward Continuing Education and Television

Item	Agree N	Agree %	Neutral N	Neutral %	Disagree N	Disagree %
1. The content of continuing education courses should be job specific.	37	49	13	17	26	34
2. Obtaining college credit is important to me in taking continuing education courses.	11	14	22	29	43	57
3. Generally continuing education courses do have direct payoff in terms of job performance.	58	76	12	16	6	8
4. Things change so rapidly in our field that I really feel the need to continue my education.	71	93	3	4	2	3
5. I prefer general courses covering broad principles to very specific "how to do it" kinds of courses.	25	33	35	46	16	21
6. My experience with instruction via TV has generally been good.	41	54	25	33	10	13

The response patterns on items one and five indicate that the students are split on the issue of course specificity. One of the courses had an unfavorable reaction to it because it was "too abstract." Yet the responses suggest that many students recognize the need for and are acceptant of general (abstract) courses. The response pattern supports the need for continuing education programs to have a variety of offerings or examples in single offerings to accommodate the varied needs and abilities of the students.

College credit is not of primary importance. The responses to item two are supported by the fact that one student to date has opted for course credit.

The respondents definitely feel the need for participating in continuing education. Furthermore they perceive a direct payoff from participation. These responses are quite different from those of the training officers. The training officers did not feel that personal obsolescence was a critical issue in their companies, and they also felt that direct and immediate payoff from continuing education cannot usually be demonstrated.

A majority of the respondents indicated good experience with instructional TV. For most this experience was probably with the SURGE program.

The students responded to several open-ended questions that asked for suggestions for courses and improvement of the procedures and course content. Many course suggestions were offered. They included English, mathematics, more statistics, computer programming, cognitive science, manufacturing

processes, communication theory, circuit design, operations research, economics, petroleum engineering, electronics, management, data processing, digital filtering and meteorology. Several indicated that they would take additional courses that are already available in the ERG program.

Another question asked the student what they liked about the program as they had experienced it. The most common answer by far was the flexibility that the course offered in terms of viewing the tape and doing the work. Several also commented that the study guide was useful and they appreciated the close coordination between the study guide material and the videotapes.

Under suggestions for improvement, there was comment about tape quality and length. Several indicated that the tapes could be shorter. More teacher contact was another suggestion. The most common suggestion was that the courses be made more practical with relevant illustrations and problems. There were some, however, who felt the course they took was too elementary and needed to be upgraded to graduate level work. Again the split noted earlier on the first attitude question is evidenced. One respondent offered the useful suggestion that the course descriptions include an assessment of difficulty and an indication of important prerequisites.

In summary, the students were very receptive to the ERG program and quite receptive to the courses. They clearly feel a need for continuing education and also feel that this need can be well met with a program such as ERG. Receiving college credit for continuing education does not seem to be a major

determiner of participation. The issue of course specificity or immediate applicability was not clearly resolved. Many respondents indicated that the courses should be very practical, but others seemed to be more oriented toward learning theory and principles. Perhaps both needs can be met by a single course if the study materials contain many problems and illustrations from different applications. On the other hand, the program might attempt to have a variety of courses in the same area, some more practical than others. For example, the ERG program now includes two calculus courses that differ in terms of level of abstraction. It would be useful to attempt this in other content areas.

Faculty Issues

Forty three faculty members at CSU were interviewed regarding their perception of the role of the teacher and the use of videopublished materials. Thirteen of the interviewees were instructional staff in the ERG program, and the remaining thirty were randomly drawn from the list of names in the CSU staff directory. The two sets of interviews are discussed separately followed by summary comparative statements.

ERG Instructional Staff

Table 7 contains a summary of certain descriptors of the 13 faculty who participated in the ERG program.

Most of the staff members have been on the CSU staff for a considerable length of time and maintain a regular teaching load. All of the ten who have been involved in non-traditional teaching have taught in the SURGE program. Some have also

Table 7

Descriptors of ERG Instructional Staff

Position		No. of Years in Position		Teaching Load		Involved in Non-traditional eaching Before	
Rank	N	Years	N	Sem. hrs.	N	Yes	No
Instructor	1	2-3	3	3	3	10	3
Assistant Professor	3	4-5	5	5	3		
Associate Professor	3	6-7	0	6	5		
Professor	4	8-9	1	8	2		
Professor & Dept. Head	2	10-11	2				
		16	1				
		26	1				

worked with computer assisted instruction and/or other kinds of videotaped courses.

The interviewees were asked why they agreed to participate in ERG. Seven, all in the College of Engineering, indicated that they were asked to do so by the Dean. All of these, however, also indicated that they were interested in the idea and committed to continuing education programs. Other expressed reasons for participating were in terms of commitment to continuing education and wanting to learn from the experience. Only one specifically indicated that the extra pay was important. One staff member indicated that he was forced to participate and really did not want to do so. This person was not sympathetic with the idea and felt that the ERG course with which he was involved would not be a

quality educational activity for the students because they would not have adequate background for the course.

In order to study the issue of what factors are important in evaluating videopublished materials, the interviewees were asked to rate the importance of various factors in evaluating both textbooks and videopublished materials. Table 8 contains a summary of the results.

Table 8

Rating of Importance by ERG Staff of Various Factors in Selecting Textbooks and Videopublished Materials (Numbers in table are of number of persons respond- at each point on the five point scale)

	Textbook					Videopublished Material				
Factor	Not Important				Very Important	Not Important				Very Important
	1	2	3	4	5	1	2	3	4	5
Author	5	2	2	2	2		1	2	3	7
Publisher	7	2	3	1						
Instructor Affiliation						3	1	8	1	
Supplemental Materials	1	5	4	3			2		6	5
Content				3	10				4	9
Technical Quality			1	8	4				6	7
Length	4	5	3	1						
Teachability		2	1	5	5					
Complete course							3	4	3	3
Flexibility (modules)							1	5	4	3
Cost						1		4	5	3

Other Factors mentioned

Cost - 4 respondents

Writing style - 1 respondent

Recency - 2 respondents

Lecture style - 2 respondents

Short turn-around for student work - 1 respondent

Prerequisites needed - 1 respondent

Audience size - 1 respondent

The data indicate that for both kinds of materials, content and technical quality are the two most important factors. The author is considered more important for videopublished materials than for textbooks. The same difference is observed for supplemental materials. Generally, however, because of the importance given content and technical quality, it appears that the important criteria for evaluating textbooks and videopublished materials are quite similar.

Attitudes of the interviewees toward the use of video materials for teaching were assessed by asking for agree-disagree responses to six attitude statements. Table 9 contains a summary of the responses.

Table 9

Attitudes of ERG Staff Toward Use of Video Materials for Teaching

	Strongly Agree	Agree	Neutral	Dis-agree	Strongly Disagree
1. A teacher who uses packaged courses is not performing adequately as a teacher.		4	2	5	2
2. Generally it is easier to build your own course than to adopt another person's course.	3	4	5	1	
3. Packaged courses are too impersonal.	1	3	1	7	1
4. Students don't like packaged courses.	1	5	2	4	1
5. Courses developed at one institution usually don't meet the needs of students at other institutions.	1	4	1	7	
6. The instructor should change the course some each time it is taught.		8	2	3	

There was considerable variation among the respondents to the items, and many of them qualified their answers with statements that indicated that they had difficulty making a response to the statements generally. The response trends indicate the following attitudes.

1. Use of a packaged course is not inconsistent with the role of a teacher.
2. Adopting a purchased course may be a more difficult task than building one's own course.
3. Packaged courses are not necessarily impersonal.
4. Students do not hold strong opinions about the use of packaged courses.
5. Courses can generalize across institutions.
6. Courses should change as they are taught.

Perceptions of the role of the teacher were also obtained in the interview. Table 10 contains a summary of the responses.

Table 10

Perceptions of ERG Staff of the Importance of Various Factors to the Role of Teacher

Role	Not Important 1	2	3	4	Very Important 5	Most Important	Least Important
1. Course Planning			1	7	5	4	1
2. Material Selection				7	6	2	
3. Lecturing			1	4	8	4	
4. Tutoring		2	2	5	4		3
5. Building Problem Sets			5	6	2	2	3
6. Testing			4	7	2	1	2
7. Motivating			1	4	8	6	3
8. Interacting with Students		1		8	4		4

The last two columns in the table contain the number of times a factor was judged to be one of the two most important and one of the two least important roles.

The respondents were quite traditional in their perception of teacher role. Course planning, material selection, lecturing, and motivation are the most important aspects of the teacher role. These results suggest that some of the resistance to the use of videopublished materials may be related to a perception that the use of such materials is inconsistent with appropriate teacher roles.

General Faculty

A phone interview was conducted in October 1975 with a random sample of 30 faculty members at CSU. The ERG instructional staff members were excluded from the sample frame as well as all in administrative positions. The sample included faculty members from 23 departments. Their average tenure at CSU was 7.4 years. Eight were professors, eight were associate professors, seven were assistant professors, and seven were instructors.

The purpose of the interview was to assess attitudes held toward the use of videotapes in instruction. Thirteen of the thirty had used videotape for instruction at some time prior to the interview.

The respondents were asked to rate the importance of various factors that might encourage or discourage the use of videotapes. The results are summarized in Table 11.

The users are quite enthusiastic about the usefulness of videotape, and the non-users are such by choice. This is reflected in the comments made as much as in the data in Table 11.

Table 11

Relative Importance of Various Factors to Usage of Videotape for Instruction

Statement*	Quite Important	Important	Not Important
1. Tapes are purchased and available in department	6	3	5
2. Used upon suggestion by colleagues	2	4	9
3. Allows presentations otherwise not possible	10	1	4
4. Department cannot afford to develop or purchase videotapes	2	2	9
5. Live instruction is preferable to videotaped instruction	10	0	2
6. Videotapes are not available for courses in my area	7	3	3
7. Videotapes are inappropriate for courses in my area	3	2	7

*Statements 1, 2, and 3 asked of those who have used videotape or plan to soon.
Statements 4, 5, 6, and 7 asked of those who have not used videotape.

The users cited advantages of videotape such as taping unique events, providing variety of format, better use of guest speakers, demonstrations of procedures, and special programs. The non-users commented that there was a lack of good materials, takes too much time and effort, cuts personal contact, and tapes soon became outdated.

At the end of the interview, the respondents were asked if they would develop their own videotape course materials if given the opportunity to do so. They were first asked this in

terms of an entire course. All of the users responded "yes," all of the non-users responded "no." When asked the question in terms of developing supplementary materials for a course, however, only two respondents answered "no."

The interviewees were asked if they detected resistance to the use of videotapes that were developed at a place other than CSU. Thirteen responded "yes" while 14 answered "no." Three persons did not answer the question. Reasons for resistance that were mentioned included the following: poor quality, instructors feel they should develop their own course and be in the classroom, materials developed elsewhere are not appropriate for Colorado, the ego of the instructor, lack of current materials, do not meet specific needs, and just stubbornness. Those who have not detected resistance generally felt that quality is the important consideration, and location of production is not important.

The results of this survey are similar to those obtained in a similar survey done a year ago at CSU of use of the services of the Office of Educational Media by faculty. The faculty seem to be in one of two camps. There are the heavy users or non-users and few what might be termed moderate users. Clearly many faculty are not just apathetic about the use of videotapes for instruction, they resist it. There are also many who are enthusiastic users. This last statement is encouraging in the sense that there is a sizable number of supportive persons who will provide the talent pool for producing courses that can be used in programs like ERG.

From the perspective of CSU faculty, resistance to importation of videopublished materials is largely related to course quality, course relevance and currency, and perception of instructor role. Thus, lowering of the resistance might be accomplished by focussing on these sources. The first two, especially are amenable to corrective efforts. Clearly a quality course is the goal of any developer, but it is perhaps especially important if the intent is to distribute the course beyond the developing institution. Relevance and currency might be improved by allowing and encouraging potential users to revise the course to be appropriate to their students and situation.

University Issues

It is reasonable to expect that use of media and videotapes by faculty is related to some extent to the degree of support given to the use of such materials by department heads and deans. If media usage in teaching is rewarded, the result would surely be usage by faculty. If, however, it is not rewarded or even discouraged, it is likely that faculty would not use it much.

In order to determine the attitudes of department heads and deans toward media usage generally and toward use of imported videopublished materials specifically, structured interviews were conducted with eight of the nine college deans at CSU and 17 department heads selected randomly. One college was in the process of hiring a new dean so no interview was conducted in that college.

Four items in the interview were structured so that the respondent indicated extent of agreement with the statement.

They were also encouraged to comment on the statement. Two items were open-ended. The results are discussed separately for each item. The responses of the deans and heads were not different so they are pooled together in this presentation.

Item 1 - It is preferable for faculty members to use video-tapes developed at CSU over those developed elsewhere.

Agree	Neutral	Disagree
8	8	9

Those who agreed with the statement generally felt that tapes developed locally would be better geared to CSU students and would be used more by the developer than those developed elsewhere. One respondent felt that it is less expensive to produce your own tapes than to purchase from others.

The respondents who were neutral or disagreed felt that quality of the tapes is the important consideration not where they are produced. Some respondents recognized the argument that tapes should be produced by those with the expertise. One respondent felt that CSU does not have the budget to produce quality tapes and needs to purchase them elsewhere.

Item 2 - Teachers using packaged courses developed elsewhere are short-changing their students.

Agree	Neutral	Disagree	No Answer
4	5	14	2

Generally the respondents disagreed with the statement. Many commented that it was difficult to respond in general because it was very much dependent on the quality of the course and on course objectives. Some common reasons for negative attitudes toward the use of packaged courses were reflected

by comments of those who agreed with the statement. These comments included "tapes should be used only as a supplement," 'tapes should only be used in teaching skills," and "a faculty member should be able to exhibit enough initiative and creativity to develop his/her own course."

Those who disagreed recognized the availability of excellent packages and the possibility of the use of courses developed elsewhere as a means of combatting provincialism in education.

Item 3 - Faculty members should be allotted time to develop their own videotape materials.

Agree	Neutral	Disagree
16	4	5

While there was general agreement with the statement, the comments indicated some interesting beliefs. A few recognized that developing quality videotapes does take time and thus supported the idea that released time should be allotted if the faculty member had the desire and need to develop such materials. More respondents, however, made comments that indicated that faculty had the time within their present teaching and research loads to develop such materials if they needed them. In effect the comments suggested that such development could and should be done in the time that the faculty member now has for course planning and preparation.

Item 4 - Videotape courses developed at CSU have not been the caliber of those developed elsewhere.

Neutral	Disagree	No Basis for Judgment
3	10	12

Generally those respondents who felt they could make a judgment responded that the video course work that has been done at CSU compares favorably with what has been done elsewhere.

Item 5 - What are your feelings regarding videopublishing by faculty members?

The administrators were very positive in their response to this question. Their answers generally were that videopublication was a creative endeavor similar to a book or an article and was truly scholarly work. Two respondents were more negative, however. While they would not discourage videopublishing, they felt it was more like developing a course than being a true scholarly activity.

Item 6 - What are the benefits and limitations of using video materials developed elsewhere?

The benefits that the administrators perceived were in terms of economics and the availability of talent in certain areas. The idea was expressed that the university should accumulate a wide array of videotapes in many areas with the intent of having available many things that could be used for personalized instruction.

One perceived limitation was also economic in the sense that much of what may be purchased may not be used. Other perceived limitations were in terms of the rather rapid outdating of materials, copyright problems, and the possible tendency for faculty to rely too much on the materials.

Summary

The Deans and Department Heads were not opposed to use of videotape. On the other hand, they were also not enthusiastic.

A general theme in the interviews was a feeling that technology has not fulfilled its potential yet in education. Present technology is adequate perhaps, but it is not outstanding, and not being used in a way to generate strong support.

The lack of enthusiastic support by the administration for the use of videopublished materials suggests that their use will not be widespread at CSU. Such activity by faculty is not clearly rewarded which makes it unlikely that faculty will devote much effort to their use.

Other Issues

In the faculty interviews, the interviewees were asked how important the institutional affiliation of the author was in their evaluation of the videopublished materials. The faculty indicated that such affiliation was somewhat important in their evaluation decision. We decided to conduct a small experiment to study whether the institution credited with production of a videotape affects students' judgements of the quality of the tape. The experiment is described below.

Procedure

Two groups of Colorado State University general psychology students were employed in the present study. Subjects in each group were read the following instructions:

> "The Human Factors Research Laboratory at CSU is currently in the process of evaluating videotaped course materials for potential use at CSU. We are requesting a few minutes of your time to preview a five-minute segment of a biology course (entitled: Introduction to Cleavage) developed at either

Massachusetts Institute of Technology or here at Colorado State University. We will therefore split this group into two sections. (A group of students were then led to another room).

"Each group was then given the following additional instructions:

"When viewing the tape, we ask that you not be concerned with the actual content. More importantly, we are interested in your ratings with respect to: presentation, technical and professional quality of the taped sequence.

"You will first see the five minute tape, and will then be asked to fill out a short questionnaire.

"Please mark the top of your questionnaire whether you are reviewing the MIT or CSU tape.

"We thank you for your assistance in this project and we will be glad to discuss the results of this study with anyone interested."

The videotaped segment employed for both student groups was developed at CSU through the BIO-COTIE program. The lecturer was Dr. Steve Stack, speaking on a topic entitled: Introduction to Cleavage. With the assistance of the Office of Educational Media, two tape introductions and ending credits were overlayed on videotape segment. The first tape received the title: Introduction to Cleavage with Massachusetts Institute of Technology credited, following the five minute lecture, closing credits again cited MIT. Similarly, the second tape was introduced and concluded with production attributed to Colorado State University.

Following the presentation of the tapes to the students, a seven item questionnaire was administered.

Results

A t-test was performed comparing the overall means of the "MIT" and "CSU" groups. The analysis failed to confirm a significant difference between the two groups $t = 1.789$, $df = 12$, $p > .05$. Means from each item by school are listed in Table 12.

Table 12

Mean Ratings of Two Groups on Tape Leader Study
(5 - favorable rating to 1-unfavorable rating)

Item	MIT	CSU
Instructor's Presentation	3.77	4.21
Knowledge of Subject	4.20	4.28
Technical Quality	3.60	3.51
Graphic & Visual Aid Quality	3.70	4.0
Creativity	3.28	3.41
Rank with Other Vid. at CSU	3.15	3.43
Compared to Live Lectures	2.75	3.12

Although there was no overall significant difference between the two groups, it is interesting to note that six out of seven means were higher for the CSU attributed tapes.

It is therefore suggested that at least among general psychology students at CSU, there appears to be no evidence that students feel that videotape quality differs on the basis

of school affiliation. One might speculate that the lack of differences between the two groups may be due to several factors. First, on the basis of "school spirit," students may have overcompensated for CSU and thus raised the CSU rating scores. By contrast, viewing a tape from MIT may have raised expectations to a level above the quality of the tape actually reviewed, thus resulting in lowered rating scores. There was some evidence to support the higher perception of prestige of MIT. Following the study students were asked about their perceptions of MIT, and nearly all indicated that MIT was viewed as more prestigious than CSU.

Administrative and Budgetary Issues

Like most continuing education activities conducted by universities, professional societies or businesses, the ERG program must become self supporting economically. In its first year of operation, ERG did not cover its direct expenses, but the potential for doing so within the next two years appears reasonable. This section will discuss some of the principal economic factors.

First it should be noted that CSU does not have exclusive rights to any of the instructional materials used in the ERG program which are produced by others. The firms or individuals who participated in ERG can generally also obtain these materials for rent or purchase directly from the producer. Prices for direct rental and, of course, purchase are set dollar values independent of the number of people served, except for study guides and books which are unit priced. The

users of the ERG program recognize this fact. Either the CSU charge per student is less than direct order, or if the CSU total fee is greater, some services provided as a part of the ERG program other than use of instructional materials must be worth the cost differential. Examples of such services are program identification and screening, student advising, tutoring, examining or credentialing. Some comments on each of these potential services is included in the evaluation. A more pragmatic reason which may be quite effective was not mentioned earlier. The budgets and procedures of the user firms have accommodated the SURGE program for eight years under the tuition refund program of the employer. Ultimately, the ERG program has also been handled in this manner and thus becomes a general overhead item for the employer. On the other hand, some employers treat direct rental or purchase of instructional materials as a direct expense to be borne by the direct operating budget of the unit and internal procedures may be more cumbersome in some instances. Every employer with which we are dealing appears to have an adequate tuition refund budget. Thus the ERG program may make the educational materials more easily reimbursable.

Direct costs to the university are conveniently categorized as follows:

(1) instructional materials

(2) faculty reimbursement

(3) distribution

(4) program management

Both items (2) and (3) are truly variable costs which scale directly with the number of students or groups served. Item (2) is relatively larger, currently amounting up to forty percent of income generated above a minimum necessary to obtain the materials, or item (1). Program management, in practice, is a fixed cost. Certain duties are assigned with budget coverage at the beginning of the year and these usually remain fixed over a years' operation. For a small program just starting its growth such as ERG, this cost must be subsidized. When the program matures, program management should amount to no more than thirty percent of gross revenue; in the first year, this cost was considerable more. The cost of instructional materials varies from course to course depending on the terms of the CSU-producer contracts. In one instance, the materials (videotapes and study guides) are essentially placed on consignment with CSU and all income derived from use is split 60% to the producer and 40% to CSU. In this instance, item (1) is a true variable cost. For another supplier, a fixed fee is charged to reproduce the tapes for CSU and no royality payment is required. Here item (1) is a fixed cost. But for the majority of the courses, CSU must pay a set fee to obtain the videotapes for use in the ERG program, plus a royality based on income. As might be expected from this description, the initial financial investment and the economic breakdown point in terms of student use varies widely from course to course. Stated differently, CSU has entered into a variety of contracts which generally reflect the producers desires and CSU has priced these programs at a slight premium above the existing SURGE

program. The latter fee structure is competitive with extension offerings in the state and for groups of students less than ten, competes well in terms of cost with live instruction from moonlighting faculty or employer staff.

How can one estimate the potential size of programs like ERG? That is, how many total student hours might a fully-developed ERG program of continuing education contact annually, in comparison to the companion graduate programs like SURGE? Table 13 shows the growth pattern to maturity of SURGE in terms of head count enrollment in 30 hour (3 quarter credit) courses, and for 1975-76, 45 hour (3 semester credit) courses. In terms of tuition income and student contact hours, the growth of SURGE is plotted in Figure 1. The first year of the ERG program is also shown in this figure. The population potentially interested in continuing education versus graduate credit is at least five times as large, but ERG clearly has an inadequate curriculum to date to significantly tap this potential. To illustrate the last point, consider Figure 2. Here the number of students served in SURGE per course is plotted to provide a reminder that total program size is tied almost directly to the number of course offerings. For example, during the last five years the SURGE program has increased from 29,280 to 43,470 student contact hours annually (Fig. 1), and all of this growth must be attributed to the addition of course offerings because as Figure 2 shows, the enrollment per course has remained a constant of 12 students/course.

Many more continuing education courses are planned for video-publishing in the near future by the Association for Media-Based

Table 13

COLORADO STATE UNIVERSITY

SURGE ENROLLMENT SUMMARY

1967 - 1976

	Number of Courses	Number of Locations	Number of Students On-Campus	Number of Students Off-Campus	Total/Yr. Off-Campus
Fall, 1967	4	7	105	189	
Winter, 1968	9	9	132	249	
Spring, 1968	8	9	100	206	644
Fall, 1968	12	13	283	341	
Winter, 1969	15	14	305	320	
Spring, 1969	13	15	314	288	949
Fall, 1969	15	14	209	336	
Winter, 1970	14	14	262	295	
Spring, 1970	14	14	162	165	796
Fall, 1970	17	15	232	403	
Winter, 1971	20	19	289	316	
Spring, 1971	18	16	235	202	
Summer, 1971	6	6	67	51	972
Fall, 1971	22	23	410	351	
Winter, 1972	24	22	353	284	
Spring, 1972	23	20	331	253	
Summer, 1972	7	10	79	93	976
Fall, 1972	32	24	527	426	
Winter, 1973	30	28	750	426	
Spring, 1973	31	29	367	275	
Summer, 1973	17	16	96	150	1,277
Fall, 1973	38	26	427	544	
Winter, 1974	38	27	337	506	
Spring, 1974	31	31	416	270	
Summer, 1974	7	11	89	130	1,450
Fall, 1974	35	36	696	494	
Winter, 1975	30	32	471	381	
Spring, 1975	32	32	403	283	
Summer, 1975	8	21	48	160	1,318
Fall, 1975*	41	35	976	472	
Spring, 1976*	39	33	547	423	
Summer, 1976*	6	18	74	71	966

*Semester system. All previous years are on the quarter system.

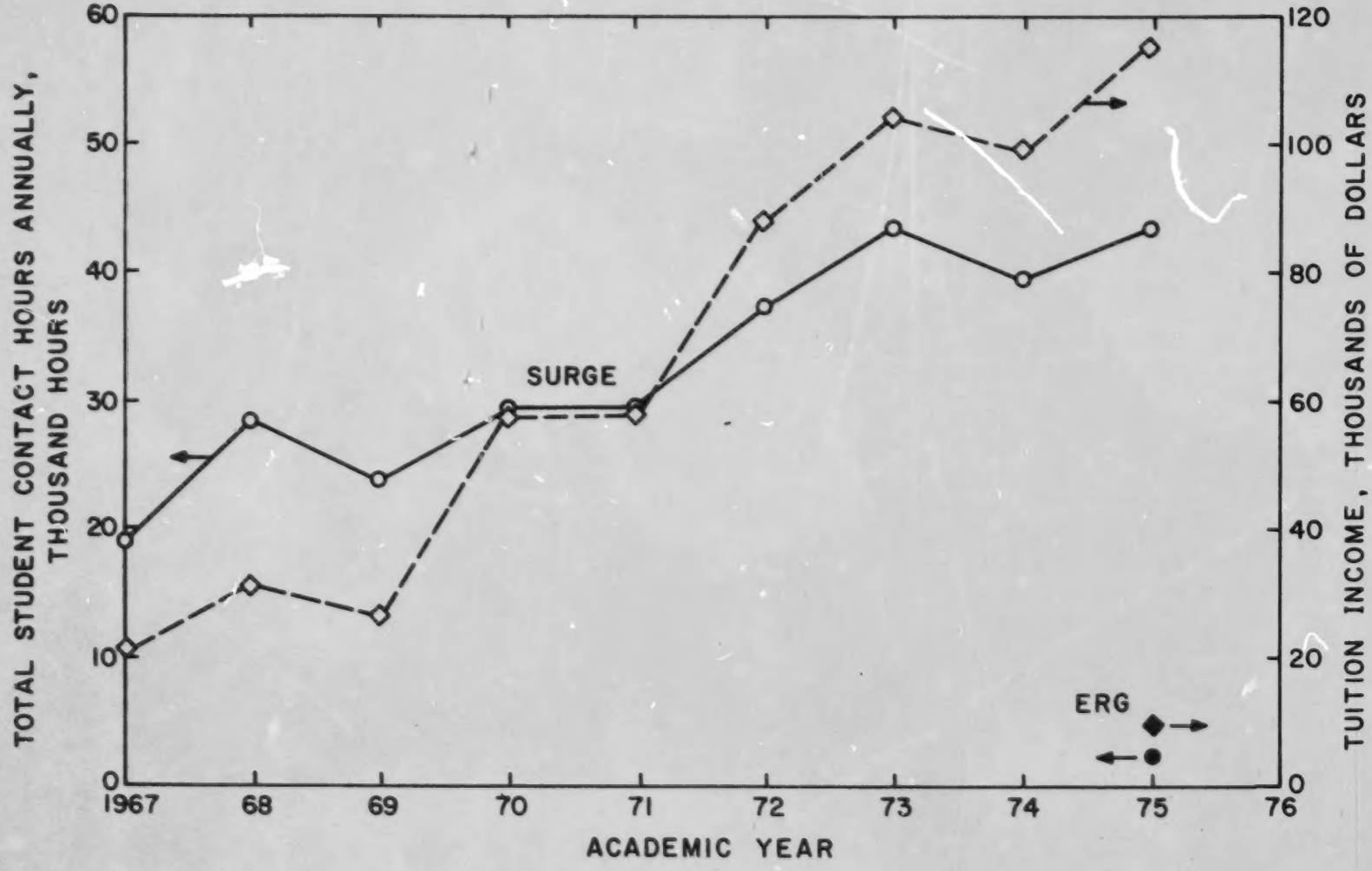

FIGURE I. GROWTH OF SURGE PROGRAM IN STUDENT CONTACT HOURS AND TUITION INCOME

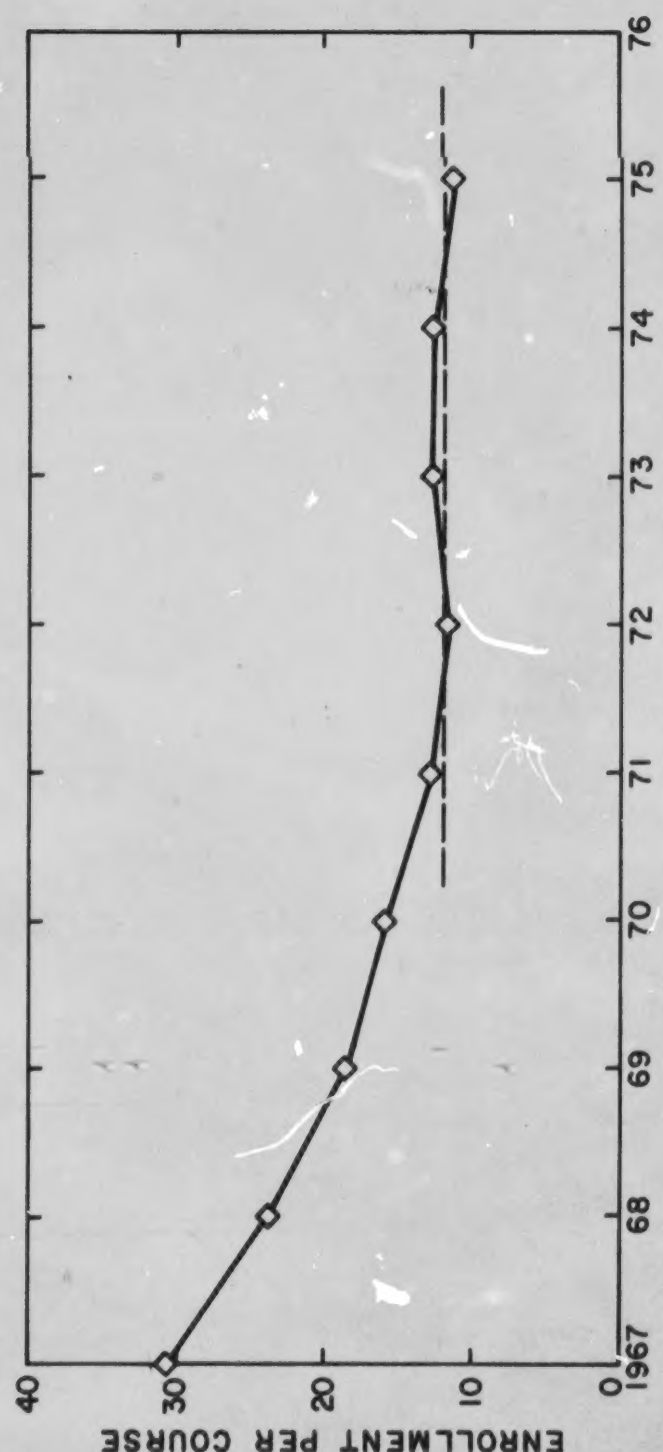

FIGURE 2. SURGE ENROLLMENT PER COURSE

Continuing Education for Engineers (AMCEE) (see refs. 16 and 17) and others, so the list of ERG offerings should grow in the range outlined in Figure 3. If we make the conservative assumption that saturation for the total population is reached at approximately the current number of contact hours in the SURGE program (40,000), then it takes approximately 133 ERG course offerings annually, or viewed differently, it will require about 6 to 12 years for ERG to reach maturity depending on the rate of new course additions. The average lifetime of the courses is probably three years or more, but in the simple projections outlined here, this attrition has been neglected.

How realistic are the projections given above? The additional use of 10 to 20 new short courses per year is feasible. Note that in the first year (actually ten months), 8 ERG courses were used from the initially available 24 selections. But 17 of these course selections are parts of series which are usually taken sequentially, so for example, orders have only very recently come for Colloid & Surface Chemistry, Part II and Modern Control Theory, Part II. Thus it would be incorrect to argue that only a third (8 of 24) of the available courses were used, and in the future, to have 10 new courses used in ERG that the catalog would have to grow by 30 courses annually. Single topic courses which are on topics of interest will circulate in the year announced. It seems reasonable to expect, therefore, that 10 to 20 new courses can be added and circulated each year for the next several years. The projections in Figure 3 assume 300 student contact hours per course, which is representative of the first year experience with ERG

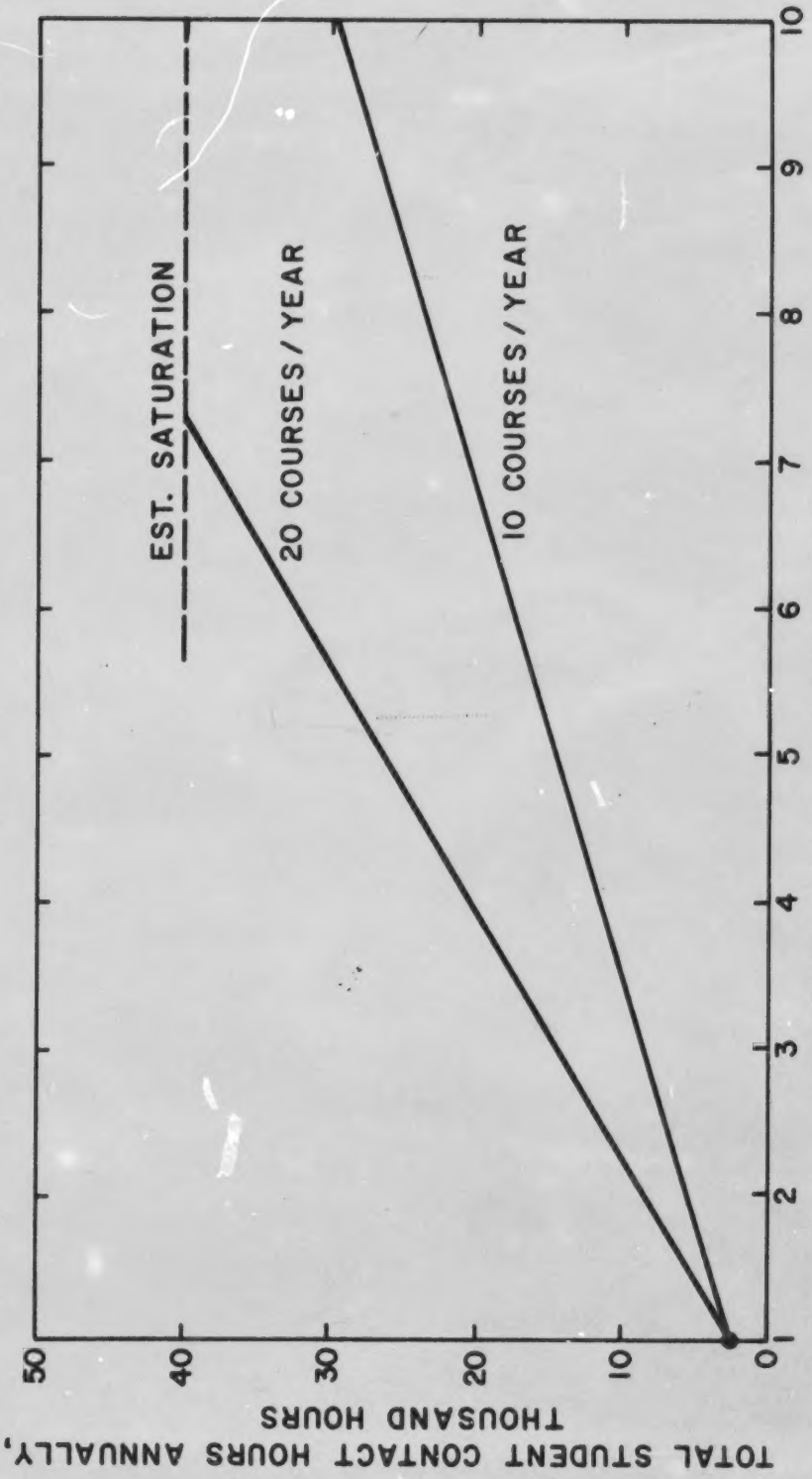

FIGURE 3. PROJECTED GROWTH OF ERG PROGRAM

(2406 student contact hours total from 8 courses). The early portion of the projection is realistic.

But is the assumed mature program level of 40,000 student contact hours abnually feasible? The age distribution of the ERG participants to date offers some insight when compared to other data.

Age	1975-76 ERG Participants (Total)	1972 U.S. Engineering Population (Total; ref. 18)	1971-72 SURGE Participants (Sample; ref. 9)
less than 25	13%	2.1%	20%
25-34	54%	26.9%	65%
35-44	28%	29.3%	13%
45-54	5%	26.0%	2%
55 and over		15.6%	

Note that the graduate credit program, SURGE is skewed markedly to the younger population while ERG much more closely parallels the characteristics of the general engineering population with the principal exception being an under representation of the over 45 age group (assuming that Colorado is a typical sample of the U.S.). Through proper choice of subject matter, ERG might in the future serve a more representative cross section of the engineering population of the state. The total engineering population in Colorado was estimated to be 20,000 people in 1973 (ref. 19). Thus, SURGE which reaches approximately 700 people annually (making an allowance for repeat enrollments) is reaching about 3.5 percent of the total. The "saturation) limit shown in Figure 3 for ERG is, therefore, probably conservative.

In conclusion, the first year of ERG was modest, but there appears to be no financial barrier to the projected growth and eventual economic self sufficiency. The limiting factor now appears to be the availability of videobased short course materials. The first year of ERG shows that suitable material is now being produced on a very limited basis by universities, a government research laboratory and industry.

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Appendix A

ENGINEERING RENEWAL & GROWTH

College of Engineering
Colorado State University
Fort Collins

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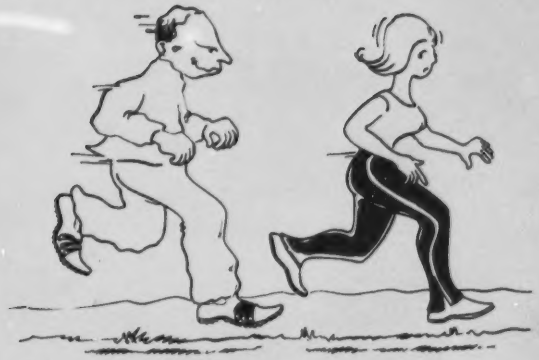
WHEN?	20

Colorado State University does not discriminate on the basis of race, color, religion, national origin, sex, or handicap. The University complies with the Civil Rights Act of 1964, related Executive Orders 11246 and 11375, and all civil rights laws of the State of Colorado. Accordingly, equal opportunity for employment and admission shall be extended to all persons and the University shall promote equal opportunity and treatment through a positive and continuing affirmative action program.

WHAT?

1. Renew Old Skills



2. Maintain Qualifications and Keep Up With New Developments in Your Field

3. Acquire Additional Specialties and/or Capabilities

WHY (not)?

Why bother? If you haven't made it by 40, you won't.

There's no sense even thinking about it. Before I could handle that course I'd have to spend a year just brushing up on my math (or physics) (or chemistry).

Don't try to con me with that "Fifteen years out of school and you're obsolete." talk! Am lucky to get an hour and a half a day with the kids as is, and damned if I'm going to give up any of that time to play schoolboy.

No way am I going to take any technical courses and get the boss to thinking maybe I'm behind the times. Might be different if this outfit gave you time off for class and helped pay the cost, but it's all "Put out or get out!" around here.

CAN'T HACK IT?

GONNA QUIT?

THEN READ NO FURTHER!

This is not for you.

HOW?

Set aside a few hours a week with several co-workers for organized study on the job. No commuting, and you never miss a lecture! You use videotaped lectures, short (30-40 minutes), well-illustrated presentations by engineers of the Center for Advanced Engineering Study at M.I.T. The course material was selected for working engineers to provide instruction in three broad areas:

- Skills refurbishment in mathematics.
- Skills supplement in subjects not usually covered in the engineering curricula of 10-20 years ago.
- Skills update in new techniques in processes and applications.

Each topic is explained in a coordinated set of instructional materials. You get a printed study guide with lecture comments, reading assignments, application problems and self-administered quizzes. The video lectures are captured in the printed guides in photographs of all the blackboard or slide material used. A textbook develops the subject matter in detail. Problem and quiz solutions are provided to help you interpret the results of your study.

It works! Literally thousands of engineers across the U.S. and Japan have used these materials successfully in recent months.

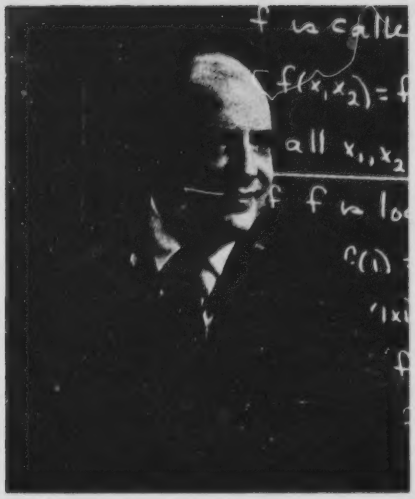
Colorado State University can now provide this new resource as part of its program for Engineering Renewal and Growth (ERG). We hope to reach engineers who do not participate regularly in the SURGE program because the graduate school or academic orientation of our offerings to date has not suited their needs. In ERG, you don't enroll, don't take exams, don't compete with campus students for grades. You simply form a self-study group to explore a topic, lease or buy the instructional materials (tapes, study-guides, texts) and pace yourself. A CSU faculty member who has previewed the set of materials will meet with you at the outset, if you like, to ensure that your background and goals are well tuned to the M.I.T. package. If desired, we can arrange such a meeting prior to the lease.

Suppose you don't find the topic you are looking for in this booklet? Give us a call or drop us a note explaining what you want. We are working with M.I.T. and several other universities who are currently producing videobased materials for practicing engineers. We may be able to find what you want. If not, the CSU Center for Continuing Education may be able to arrange for an instructor to come to your facility.

CREDIT?

Is it possible to receive academic credit or continuing education credit from CSU for successfully completing an M.I.T. course? In most cases, YES, but we don't expect many engineers to request credit. For the ERG participant who desires academic credit, the CSU faculty adviser for that course will prepare a final examination. A passing grade in this exam will be noted in your official CSU transcript as "credit by examination" in the equivalent regular CSU course. There is a special fee (currently $20.00/course) for this extra activity. Continuing education units (CEU) or credit is simpler because CEU credit only indicates attendance in the course, no exam is necessary. The CSU Center for Continuing Education can provide you with a certification of CEU credit when you complete the course and pay an extra fee of $3.00/person. If you seek formal credit, contact the ERG Field Representative and he will help you through the maze!

SKILLS REFURBISHMENT



CALCULUS REVISITED

Part I: Calculus of a Single Variable

Functions; limits; derivatives and integrals for polynomials; rational functions; trigonometric, exponential and logarithmetic functions plus infinite series which covers standard test for convergence; power series and applications.

Thirty-eight 30-minute lectures, pretest, study guide, lecture notes and text.

Part II: Calculus of Several Variables

Vector algebra; vector differentiation and its use in velocity and acceleration; partial differentiation and its application to maxima and minima; multiple integration and its application to area; complex numbers; algebra of complex numbers; differentiation of functions of a complex variable; integration of functions of a complex variable.

Twenty-six 30-minute lectures, pretest, study guide, supplementary notes and text.

Herbert E. Gross
Senior Lecturer
Massachusetts Institute of Technology

For 25 years Herb Gross has been teaching math to youngsters in elementary schools, to freshmen at M.I.T., to students in a community college, and more recently, to the Fellows of the Center for Advanced Engineering Study at M.I.T. His experience comes across in all three parts of Calculus Revisited.

Part III: Linear Algebra and Differential Equations

Vector spaces; linear dependence and independence; systems of linear equations; matrices; standard techniques for solving differential equations of first order and also higher order; method of undetermined coefficients and variation of parameters; numerical solutions; series solutions; eigenvectors and orthogonal functions.

Twenty 30-minute lectures, pretest, study guide, supplementary notes and text.

Text for all three parts of Calculus Revisited is *Calculus and Analytic Geometry*, G. B. Thomas (4th Ed.), Addison Wesley, 1968.

Ralph H. Niemann
Professor of Mathematics
CSU Faculty Adviser

SKILLS SUPPLEMENT

ECONOMICS

Robert S. Pindyck
Assistant Professor of Management
M.I.T.

Charles F. Revier
Assistant Professor of Economics
CSU Faculty Adviser

Part I: Microeconomics

This course relies heavily on calculus and graphical analysis to present intermediate level, *not* beginning, demand and supply theory. It emphasizes the technical aspects of microeconomic theory, e.g., constrained maximization with respect to profits and equilibrium analysis. The course includes discussions on consumer behavior underlying demand theory, the theory of production and costs, and types of market structures ranging from pure competition to monopoly. Special applications on incidence of taxes, effects of price ceilings and minima, regulation of a monopoly, and price discrimination are also covered.

Twelve 45-minute lectures, study guide and optional text (*Economics*, P. Samuelson (9th Ed.), McGraw-Hill).

Part II: Macroeconomics

Macroeconomics relies heavily on the notion of models. The structure of the United States economy is approached through a series of simple algebraic models, which can in turn be applied to considerations of fiscal and monetary policy. Issues pertinent to economic institutions, particularly the commercial banks and Federal Reserve System, are discussed, including money and interest rates, integration of monetary and fiscal policy, inflation and unemployment.

Ten 45-minute lectures, study guide and optional text (*Economics*, P. Samuelson (9th Ed.), McGraw-Hill).

AN INTRODUCTION TO EXPERIMENTATION

An Introduction to Experimentation is designed to teach a systematic approach to the collection, analysis and reporting of experimental data. The major topics covered in this course are the characteristics of instruments, errors of measurement, statistical analysis, plotting functional relationships, correlation, and technical reporting.

Fourteen 30-minute lectures, study guide and text (*An Introduction to Experimentation,* E. Rabinowicz, Addison Wesley, 1970).

Ernest Rabinowicz
Professor of Mechanical Engineering
M.I.T.

Michael K. Wells
Assistant Professor of
Mechanical Engineering
CSU Faculty Adviser

FRICTION, WEAR AND LUBRICATION

This course provides an introduction to friction, wear and lubrication at a level which is suitable for engineering seniors. The major topics covered are the various forms of wear, wear characteristics and magnitudes, friction and the laws of friction, the role of lubricants. A number of related topics such as hardness, surface energy, polishing and troubleshooting are discussed.

Twelve 40-minute lectures, study guide and text (*Friction and Wear of Materials,* E. Rabinowicz, Wiley and Sons, 1965).

Fred W. Smith
Professor of Mechanical Engineering
CSU Faculty Adviser

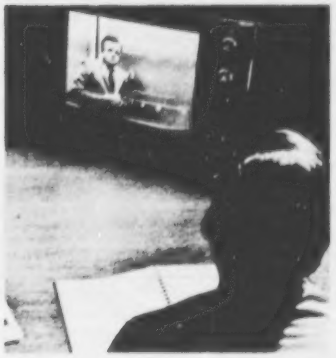
Duane C. Boes
Associate Professor of Statistics
CSU Faculty Adviser

Maurice C. Bryson
Assistant Professor of Statistics
CSU Faculty Adviser

PROBABILITY

This course is a post-calculus introduction to the theory of probability. The standard axiomatic definition of probability with the notion of relative frequency as motivation is given. The following concepts are included: conditional probability, independence, random variables, distribution and density functions, expectation, moments, joint random variables and distributions, covariance and correlation, characteristic functions, law of large numbers, central limit theorem, and random variable estimation. Applications to communications and reliability are shown. A brief introduction to statistical inference is provided; included is the method of maximum likelihood estimation. The course is divided into four blocks and should typically require approximately 15 weeks to complete.

Forty-nine 30-minute lectures, pretest, study guides, lecture notes and text (*Probability and Random Processes*, W. B. Davenport, McGraw-Hill, 1970).



Harry L. Van Trees
Professor of Electrical Engineering
M.I.T.

RANDOM PROCESSES

This course covers basic techniques in the analysis of stationary random processes and time series, presupposing a basic course in post-calculus probability. Topics include: definition of stationarity; correlation and covariance functions; cross-correlations; Fourier analysis, uses of Laplace and Fourier transforms, and time-frequency domain relationships; linear system analysis and optimum filtering; counting processes, specifically the Poisson; Markov processes, specifically the pure-birth process; uses of probability generating functions; Gaussian processes; estimation of spectral densities. The course is divided into seven blocks and should typically require about 19 weeks to complete.

Forty-seven 30-minute lectures, study guide and text (*Probability and Random Processes*, W. B. Davenport, McGraw-Hill, 1970).

SKILLS UPDATE

ARTIFICIAL INTELLIGENCE

A graduate-level survey of the techniques used in artificial intelligence, which takes the view that artificial intelligence consists primarily of describing bodies of knowledge in such a way that the processes of reasoning based on that knowledge can be described in algorithmic processes. One could, therefore, build machines to perform the algorithms which would exhibit behavior similar to that of intelligent creatures in certain environments.

Summarizes early efforts in the field, including adaptive systems like Rosenblatt's perceptron and Samuel's checker player, and shows why some of these efforts were doomed to failure. Also included is a description of the successful attempts at automatic solution of indefinite integrals by Slagel and Moses, and the General Problem Solver approach of Newell and Simon and its connection with modern theories of intelligence. However, the course deals mainly with the more successful work of the past five years on such topics as describing knowledge, solving algebraic word problems, understanding English sentences and processing natural language.

Descriptions are at times couched in a high-level language (PLANNER and its relatives) which is particularly suited to the specification of algorithms used in modern work on machine intelligence; but since the basics are discussed in several lectures, no prior knowledge of the language is needed. Previous experience with computers is helpful, although not really necessary. The course requires only high-school algebra and geometry.

Twenty-four 30-minute lectures, study guide and text (*The Psychology of Computer Vision*, Patrick H. Winston, ed., McGraw-Hill, 1975).

Patrick H. Winston
Associate Professor of
Computer Science
M.I.T.

Rex L. Page
Assistant Professor of
Computer Science
CSU Faculty Adviser

J. Theodoor G. Overbeek
Professor of Physical Chemistry
University of Utrecht

David M. Mohilner
Professor of Chemistry
CSU Faculty Adviser

COLLOID AND SURFACE CHEMISTRY

This series assumes no prior knowledge of surface chemistry, but is intended for people holding a B.S. in either chemistry or chemical engineering. Anyone with the equivalent of a semester of physical chemistry and a semester of organic chemistry would also qualify. It is *not* a survey course, but rather a graduate-level course in surface chemistry with example applications.

Part I: Surface Chemistry

Topics are discussed in the following order: introduction; surface tension and surface energies; measurement of surface tension; adsorption; thermodynamics of fluid interfaces; spreading; surface tension and surface structure of solids; adsorption of gases on solids; chemisorption; adsorption from solution; energies and entropy of adsorption; theory of electrocapillarity; structure of electric double layer.

Sixteen 40-minute lectures, study guide and text (*Physical Chemistry of Surfaces,* A. W. Adamson, (2nd Ed.), Interscience, 1960).

Part II: Lyophobic Colloids

Stability of lyophobic colloids; interaction between double layers; spherical double layers; Van der Waals' forces; colloidal stability; foams and soap films; emulsions; protective action; rheology; sol preparation; particle size determination; flocculation kinetics.

Fifteen 40-minute lectures, study guide and text (*Colloid Science,* H. R. Kruyt, ed., Vol. I, Elsevier, 1952; and *Physical Chemistry of Surfaces,* A. W. Adamson (2nd Ed.), Interscience, 1960).

Part III: Electrokinetics and Membrane Phenomena

Zeta potential; electrophoresis; electro-osmosis and streaming potential; nonequilibrium thermodynamics of electrophoresis and sedimentation potential; membrane potential; the Donnan equilibrium.

Nine 40-minute lectures, study guide and text (*Colloid Science,* H. R. Kruyt, ed., Vol. I, Elsevier, 1952).

Part IV: Lyophilic Colloids

Solutions of lyophilic colloids; examples of macromolecules; polymer synthesis; statistics of polymer coil conformations; viscosity of polymer solutions; rubber elasticity; thermodynamics of polymer solutions; osmotic pressure; molecular weight distributions and determinations; light scattering; the ultracentrifuge; polyelectrolytes; coacervation; association colloids; gels.

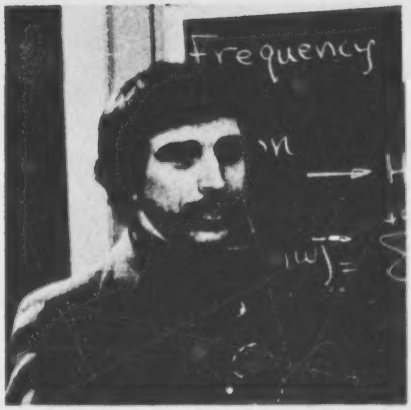
Fifteen 50-minute lectures, study guide and text (*Principles of Polymer Chemistry,* Paul J. Flory, Cornell University Press, 1953).

DIGITAL SIGNAL PROCESSING

An integrated program designed to provide an understanding of and working familiarity with the fundamentals of digital signal processing, this course begins with the definition of discrete-time signals and systems, and proceeds through a thorough treatment of such digital signal processing fundamentals as difference equations, discrete-time Fourier transforms, the z-transform, digital filter design and implementation, and the fast Fourier transform.

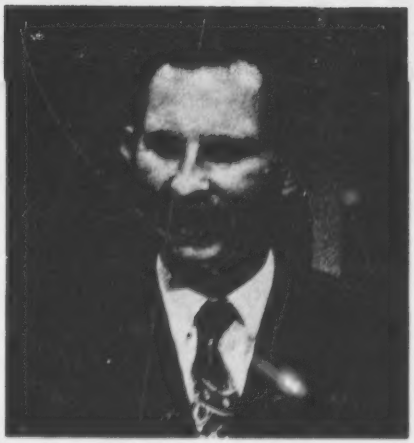
The course assumes familiarity with introductory complex variable theory, a previous exposure to linear system theory, including Laplace and Fourier transforms, and some experience with discrete-time signals, z-transforms and discrete Fourier transforms.

Twenty 40-minute lectures, study guide and text (*Digital Signal Processing*, A. V. Oppenheim and R. W. Schafer, Prentice-Hall, 1975).



Alan V. Oppenheim
Professor of Electrical Engineering
and Computer Science
M.I.T.

Thomas A. Brubaker
Associate Professor of
Electrical Engineering
CSU Faculty Adviser



J. R. Anthony Pearson
Professor of Chemical Engineering
University of London

Judson M. Harper
Professor of Agricultural Engineering
CSU Faculty Adviser

MECHANICS OF POLYMER PROCESSING

This series is designed primarily for engineers and technologists who are concerned with polymer processing. It is at graduate level, using mathematical modelling and traditional methods in calculus and fluid dynamics. The text for all three parts is *Mechanical Principles of Polymer Melt Processing*, J. R. A. Pearson, Pergamon Press, 1966.

Part I: Introduction

The introductory lectures describe briefly the structural chemistry, and the physics and mechanical properties of the most commonly used plastics and elastomers. Some of the most important polymer processes are demonstrated. The kinematics and dynamics of the flows are noted for two distinct patterns. The important role of flow instability is discussed, along with the application of these ideas to design and control.

Eight 40-minute lectures, study guide and text.

Part II: Fundamentals of Polymer Melt Mechanics

Part II concentrates on the fundamental mechanics of viscoelastic materials in terms of mathematical models for continuum behavior. The interrelation between conservation laws, constitutive relations and flow geometry is emphasized. Experimental methods and viscometry are discussed. Simple isothermal solutions for idealized flow systems are given.

Twelve 45-minute lectures, study guide and text.

Part III: Application to Polymer Processing

This course is concerned with the application of the fundamental ideas discussed in the previous parts to polymer processes. The importance of heat transfer and phase changes is emphasized. Mathematical models for the most important melt processes are derived and discussed. The stability of various processes is considered. Analytical approaches are used whenever possible.

Twelve 45-minute lectures, study guide and text.

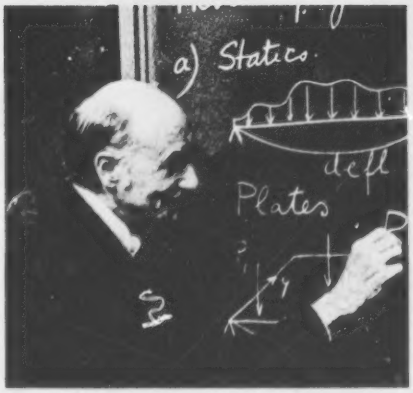
NONLINEAR VIBRATIONS

Discusses various methods — exact and approximate, numerical and graphical — of dealing with vibrations in systems. The systems are described by non-linear differential equations. The solution techniques discussed include the phase-plane method, the Vander Pol equation, Martienssen's method, and the exact approach for piece-wise linear systems. Each approach is motivated by a practical problem and applied to a number of interesting special cases.

Three specific problems are discussed in detail after the basic techniques are introduced. These are: (1) the Sommerfeld effect or jump phenomenon in the speed of rotating machinery; (2) instabilities in centrifugal pendulum, torsional vibration dampers in reciprocating engines; and (3) catastrophic vibrations in jet engines with ball bearings having small clearances.

The concluding lectures introduce the approximate methods of Krylov-Bogoliubov and of Galerkin.

Twenty-three 30-minute lectures, study guide and text (*Mechanical Vibrations*, J. P. Den Hartog (4th Ed.), McGraw-Hill).



Jacob P. Den Hartog
Professor of Mechanical Engineering, Emeritus
M.I.T.

Jack E. Cermak
Professor of Civil Engineering
CSU Faculty Adviser

Michael Athans
Professor of Electrical Engineering
M.I.T.
Director, Electronic Systems Laboratory

MODERN CONTROL THEORY

This series is a graduate-level course in modern control theory which assumes a working knowledge of vectors and matrices and their basic operations: addition, multiplication, scalar products and norms. Previous exposure to the notion of the eigenvalues and eigenvectors of a matrix would be helpful, although these concepts are briefly reviewed when they are first used. The concept of a transfer function is used for the continuous-time systems. To use the computer subroutines, an elementary knowledge of FORTRAN is sufficient.

The material presented deals with both continuous-time dynamic systems and discrete-time dynamic systems. Continuous-time systems represent the natural description of the majority of physical systems. Discrete-time systems are most often used in the description of socio-economic systems; however, discrete-time systems also arise due to sampling of continuous-time systems (sample data systems). This way of representing physical systems is extremely important because of the rising trend in the use of digital hardware for implementing control systems. The concepts of modern control theory are equally well developed for both continuous-time and discrete-time systems. For this reason, equal attention is paid to both.

Part I: System Analysis

System Analysis introduces the basic ideas required for understanding the state-variable representation and its relationship to the more traditional transfer-function representation.

Eleven 40-minute lectures, study guide, computer manual and text (*Optimal Control,* Athans and Falb, McGraw-Hill, 1966).

Part II: Deterministic Optimal Control

Deterministic Optimal Control presents the basic theoretical tools (continuous and discrete maximum principle) and two popular computational algorithms (the steepest descent method and Newton's method) which are available for solving deterministic dynamic optimization problems for nonlinear dynamical systems with realistic performance criteria.

Nine 40-minute lectures, study guide and text (*Optimal Control,* Athans and Falb, McGraw-Hill, 1966).

Part III: Deterministic Optimal Linear Feedback

Deterministic Optimal Linear Feedback specializes the general results of Part II to the very important class of so-called linear-quadratic problems. Basically, it contains a complete theoretical and algorithmic framework for designing deterministic linear feedback control systems when the system

dynamics are linear and the performance index is quadratic. Both the finite-time and infinite-time versions are presented. In addition, the results are given for continuous-time as well as discrete-time systems.

Twenty 40-minute lectures, study guide and text (*Optimal Control,* Athans and Falb, McGraw-Hill, 1966).

Part IV: Stochastic Estimation

Stochastic Estimation deals with the theoretical and algorithmic tools necessary to estimate state variables and unknown parameters based upon noisy measurements. A Baysian approach is adopted which leads to the discrete-time Kalman filter, and to the continuous-time Kalman-Bucy filter. For nonlinear estimation problems the extended Kalman filter and the second-order filter are presented and illustrated.

Seventeen 40-minute lectures, study guide and text (*Optimal Control,* Athans and Falb, McGraw-Hill, 1966).

Part V: Stochastic Control

Stochastic Control contains a general discussion of the general stochastic control problem (and of its difficulties) as well as a complete expositon of the theory and algorithms for the so-called linear-quadratic-Gaussian (LQG) problems. Both the continuous-time and discrete-time versions of the problem are considered. Also, both the finite and infinite time versions are presented. Step-by-step procedures for using the LQG theory and algorithms to control nonlinear stochastic systems are given.

Fourteen 40-minute lectures, study guide and text (*Optimal Control,* Athans and Falb, McGraw-Hill, 1966).

Computer Subroutines

In addition to the general theory, structure of computation algorithms, and examples, a set of computer subroutines has been developed which can be used to analyze and design the most important (from a practical point of view) class of problems. This class of problems is associated with linear-time invariant continuous-time dynamics, use of quadratic criteria over an infinite time interval, and Gaussian distributions. Thus, these subroutines can be used to:

1. Calculate the deterministic and stochastic response of linear-time invariant systems.
2. Calculate automatically the solution to the steady-state linear-quadratic problem, and simulate the response of the resultant deterministic linear regulator.
3. Design and simulate the steady-state Kalman-Bucy filter.
4. Design and simulate the steady-state stochastic regulator using the LQG approach.

C. Byron Winn
Associate Professor of Mechanical Engineering
CSU Faculty Adviser
Parts I, II & III

Louis L. Scharf
Associate Professor of Electrical Engineering
CSU Faculty Adviser
Parts IV & V

WHERE?

In-plant viewing of videotapes at a time of your own choosing.

At-home perusal of study guide and text to the extent appropriate for desired mastery of the subject.

The CSU Faculty Advisers will be available for telephone discussions of the subject matter at scheduled mutually convenient times, and will make occasional in-plant tutorial visits if desired.

Lease fees, including study guides but not texts, are as follows:

Subject	Charge per Person Including Study Guide
Calculus Revisited (1)	$ 95.00
Calculus Revisited (2)	65.00
Calculus Revisited (3)	50.00
*Economics (1)	54.00
*Economics (2)	45.00
An Introduction to Experimentation	42.00
*Friction, Wear and Lubrication	54.00
Probability	123.00
Random Processes	118.00
*Artificial Intelligence	96.00
Colloid & Surface Chemistry (1)	48.00
Colloid & Surface Chemistry (2)	45.00
Colloid & Surface Chemistry (3)	27.00
Colloid & Surface Chemistry (4)	45.00
Digital Signal Processing	90.00
*Mechanics of Polymer Processing (1)	36.00
*Mechanics of Polymer Processing (2)	54.00
*Mechanics of Polymer Processing (3)	54.00
Nonlinear Vibrations	58.00
*Modern Control Theory (1)	50.00
*Modern Control Theory (2)	41.00
*Modern Control Theory (3)	90.00
*Modern Control Theory (4)	77.00
*Modern Control Theory (5)	63.00
*Color videocassette	

Refer to ERG First Supplement For Price Changes Effective September 1, 1976 Due Increased Study Guide Costs.

Videotape Equipment	Monthly Rental
½" B&W Playback Unit	$ 50.00
B&W TV Monitor	15.00
¾" Playback Unit	100.00
Color 17" Monitor	40.00

WHEN?

WHY DELAY?

Contact your Education Officer today, or write:

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Office of the Dean
College of Engineering
Colorado State University
Fort Collins, CO 80523

W. L. Somervell, Jr.
ERG Field Representative
Phone: (303) 491-8417

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I would like additional information on the following ERG courses:

SKILLS REFURBISHMENT

( ) Calculus Revisited, 1
( ) Calculus Revisited, 2
( ) Calculus Revisited, 3

SKILLS SUPPLEMENT

( ) Economics, 1
( ) Economics, 2
( ) An Introduction to Experimentation
( ) Friction, Wear and Lubrication
( ) Probability
( ) Random Processes

SKILLS UPDATE

( ) Artificial Intelligence
( ) Colloid and Surface Chemistry, 1
( ) Colloid and Surface Chemistry, 2
( ) Colloid and Surface Chemistry, 3
( ) Colloid and Surface Chemistry, 4
( ) Digital Signal Processing
( ) Mechanics of Polymer Processing, 1
( ) Mechanics of Polymer Processing, 2
( ) Mechanics of Polymer Processing, 3
( ) Nonlinear Vibrations
( ) Modern Control Theory, 1
( ) Modern Control Theory, 2
( ) Modern Control Theory, 3
( ) Modern Control Theory, 4
( ) Modern Control Theory, 5

Our videotape playback equipment is:
( ) ½" tape; ( ) ¾" cassette, ( ) 1" tape; ( ) B&W; ( ) Color; ( ) None.

I would be interested in a comparable ERG course on the following subject(s).

_____

_____

Name Title

_____

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Appendix B

ENGINEERING RENEWAL & GROWTH

College of Engineering
Colorado State University
Fort Collins
FIRST SUPPLEMENT

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Colorado State University does not discriminate on the basis of race, color, religion, national origin, sex, or handicap. The University complies with the Civil Rights Act of 1964, related Executive Orders 11246 and 11375, and all civil rights laws of the State of Colorado. Accordingly, equal opportunity for employment and admission shall be extended to all persons and the University shall promote equal opportunity and treatment through a positive and continuing affirmative action program.

Thank God, you got here!

ERG SUPPLEMENT

The CSU College of Engineering is pleased to announce an expansion of the Engineering Renewal & Growth (ERG) program introduced in July 1975. The additional videotaped self-study subjects which are now available include three produced by Colorado State University, four prepared at the Association for Continuing Education at Stanford University, three developed by Texas Instruments, Inc., and one each from Lawrence Livermore Laboratory, the MIT Sloan School, and Purdue University.

As were our previously announced offerings, these new subjects are intended primarily for mid-career engineers and scientists who, because of the nature of past employment and/or the lack of suitable educational opportunities, have not been able to keep abreast of new developments in their chosen fields.

Skills Refurbishment	provide an additional although less comprehensive option in basic engineering mathematics.
Skills Supplement	present thorough treatments of subjects rarely covered adequately in the engineering curricula of yesteryear - manufacturing quality control, vacuum technology, and a rational approach to diagnostic economics.
Skills Update	continue to emphasize high-technology subjects where progressive obsolescence is most likely to overtake engineers who are not intimately engaged in research and development.
Skills Applied	introduce a new category which pertains to "acquired" management expertise in areas wherein many engineers may be deficient on the job, or in their domestic affairs to an extent which can adversely affect their ability to perform their job.

For details on how to obtain course materials for the subjects announced herein or other ERG program offerings, please refer to our 1975 ERG brochure, contact your company Education Officer, or write or phone W.L. "Slim" Somervell:

ERG Field Representative
Office of the Dean
College of Engineering
Colorado State University
Fort Collins, CO 80523
Phone: (303) 491-8417

SKILLS REFURBISHMENT

INTRODUCTION TO CALCULUS

This course is intended for individuals desiring to acquire proficiency in differential and integral calculus at a time and place of their own choosing. The lectures, together with the many solved problems in the workbook and text, permit independent self-paced study with little or no need for recourse to an instructor. However, participation in a small study group provides for interaction with others and enhances adherence to a regular viewing schedule, which experience in continuing education shows are conducive to timely course completion as well as satisfaction with the time and effort expended. Topics include: brief review of exponents, exponential functions; logarithms, linear and quadratic equations; derivations of elementary functions; application of the derivative to find maxima and minima of a given function; sequences and series; basic rules of integration.

Nineteen one-hour lectures, 200-page study guide and text (*First Year College Mathematics*, Frank Ayers, Jr., Schaum's Outline Series, McGraw-Hill, 1958).

Ralph H. Niemann
Professor of Mathematics,
CSU Faculty Adviser

Produced by the Association for Continuing Education (ACE)

Ronald Woolley
Assistant Professor of Mechanical Engineering,
Brigham Young University.

SKILLS SUPPLEMENT

ENGINEERING ECONOMY

Sanford B. Thayer
Associate Professor of Mechanical Engineering,
Lecturer and
CSU Faculty Adviser

This course provides a thorough understanding of the concepts and methodologies necessary to evaluate the impacts of interest rates, income taxes, and timing of cash flows on the economic attractiveness of investment proposals—whether corporate or personal. It is an excellent preparation for the engineering economy section of the Professional Engineers Examination. Topics include: the time value of money concept; break-even analysis; uniform annual cash-flow, present-worth, rate-of-return, benefit/cost and cost-effective methods of evaluation; effects of income taxes; replacement considerations; and sources of funds. Mathematics is limited to simple arithmetic.

Ten 25-minute lectures, 250-page study guide and optional text (*Principles of Engineering Economy*, Eugene L. Grant, W. Grant Ireson, and Richard S. Leavenworth (6th Ed.), Ronald Press, 1976).

FUNDAMENTALS OF VACUUM TECHNOLOGY

Science, engineering, pharmacy and many other classical disciplines use vacuum technology, but no discipline has claimed the field as its own and accepted the responsibility for formal training or education. This course is designed to provide some degree of formal instruction; to provide a systematic, logical learning experience on the fundamentals of the field. The concepts and terminology of vacuum systems are introduced, and the basic principles of ideal gas behavior are discussed. The course then deals with the operating principles and characteristics of vacuum pumps and gauges, from vane pumps and thermal conductivity gauges to titanium sublimation or getter ion pumps and cold cathode or radioactive gauges.

Twenty 15-minute lectures, 450-page study guide and text (*Vacuum Technology*, Andrew Guthrie, John Wiley & Sons, 1963).

Robert M. Anderson, Jr.
Associate Professor of
Electrical Engineering,
Purdue University

Paul J. Wilbur
Associate Professor of
Mechanical Engineering,
CSU Faculty Adviser

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MANUFACTURING QUALITY CONTROL

This course provides a thorough understanding of the concepts and methodologies of manufacturing quality control. Topics include: control charts for mean, range and defectives; attribute, variable and continuous sampling plans; vendor certification and rating plans; specifications and tolerances; and product liability. Details are presented on MIlitary Standards 105D, 414 and 1235.

Ten 30-minute lectures, 150-page study guide and text (*Statistical quality Control*, Eugene L. Grant and Richard S. Leavenworth, McGraw-Hill, 1972).

Sanford B. Thayer
Associate Professor of
Mechanical Engineering,
Lecturer and
CSU Faculty Adviser

SKILLS UPDATE

DESIGNING WITH MICROPROCESSORS

LEARNING CENTER

Don L. Cannon
George A. Consolver
Gerald Luecke
Jack P. Mize
Robert N. Sherman
William D. Simpson
Dan F. Thomas
Rodger S. Walker
John G. Wester

This subject is intended to provide engineers with the framework of knowledge needed to answer such questions as: Is a microprocessor right for my application? Which microprocessor should I use? What external logic will I need? The course examines design points, analyzes basic hardware requirements and outlines software capabilities, with a view to explaining what a microprocessor is and how it works, how to select a microprocessor, how a program is defined and how microprocessors can be used to develop economical solutions. Topics include: microprocessor background via digital computer system architecture; chip architecture and fabrication; use of software for microprocessors; instruction sets and interface design; potential applications and limitations in controllers, communications design, point-of-sale and other terminals, avionics, the automotive industry and entertainment; and future trends in microprocessor technology.

Sixteen half-hour lectures and lesson summary book.

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Thomas A. Brubaker
Professor of Electrical Engineering,
CSU Faculty Adviser

DIGITAL SUBSYSTEMS

LEARNING CENTER

Don L. Cannon
James L. Deans
Richard G. Moore
Jerry D. Mullen
John G. Webster

This advanced-level course will serve either as a review of basic digital techniques, or as a comprehensive introduction to digital technology for those desiring a thorough understanding of the design process and an ability to advantageously apply these techniques to their own problems. The general world of digital hardware is divided into five subsystems: arithmetic logic units; controllers; memories; input/output; and timing. Within each of these, in-depth coverage is provided on the functional capabilities of digital circuits and the application benefits they offer: simplified equipment design, increased reliability, and improved economy. Topics include: reviews of combinatorial and sequential logic; fundamental and advanced ALU; functions and types of controllers; basic concepts and applications of shift-register, random-access and read-only memories; timing of asynchronous and synchronous systems; input/output hardware and software for machine-machine and man-machine interfaces; troubleshooting; and design examples.

Sixteen half-hour lectures and lesson summary book.

NETWORK ANALYSIS AND DESIGN IN THE FREQUENCY DOMAIN

This two-part subject is intended for circuit-design engineers who want to acquire proficiency in working with modern operational amplifier circuits. The course assumes knowledge of Laplace transformation and fundamentals of circuit theory. The text for both parts is *Passive and Active Network Analysis and Synthesis*, Aram Budak, Houghton Mufflin, 1974.

Aram Budak
Professor of Electrical Engineering,
Lecturer and
CSU Faculty Adviser

Part I: The Frequency Domain - Concepts and Techniques

In Part I, useful circuit analysis techniques and concepts are developed and applied to a large number of example problems. The emphasis is on acquiring the necessary tools and skills for circuit analysis. It provides the necessary background for Part II, which deals with modelling and applications of operational amplifiers. Topics include: circuit analysis techniques - principle of superposition, equivalent circuits; dependent sources; the system function, ladder networks; natural and forced response; step and sinusoidal steady-state respond; magnitude and phase.

Eight 40-minute lectures, 60-page study guide and text.

Part II: The Operational Amplifier - Modelling and Applications

In Part II, RC-operational amplifier circuits are discussed. Ideal and one-pole rolloff modelling of operational amplifiers are used to study the characteristicsof many practical circuits. The need and interest of the circuit-design engineer are evident in the examples selected to show how theory applies in practice. Topics include: the ideal operational amplifier; linear applications; one-pole rolloff models; bandwidth; output impedance; frequency response, ideal and actual; step response; offset, slewing and dynamic range; nonlinear applications.

Twelve 40-minute lectures, 90-page study guide and text.

LEARNING CENTER

Gerald Luecke
William N. Carr
Jack P. Mize
Keith Lovelace

Carl W. Wilmsen,
Associate Professor of Electrical Engineering, CSU Faculty Adviser

SEMICONDUCTOR MEMORIES

The backbone of this course is design and application. The overriding consideration is to acquaint the systems designer with the functional capabilities of semiconductor memories and the performance benefits they offer over traditional systems: simpler architecture, reduced power dissipation, faster access and cycle times. The intent is to provide that understanding needed to better evaluate the suitability of each technology in proposed applications, weigh the relative advantages of available options, and work with suppliers for cost-effective systems. Topics include: memory functions and economics; semiconductor technology arsenal for storage elements; reliability of semiconductor memories; and the design and application of the various types and sizes of fixed-program, sequentially accessed, and high-speed and MOS random-access storage cells and memory systems.

Eleven one-hour lectures and lesson summary book.

MICROPROCESSOR TECHNOLOGY & APPLICATIONS

A course in the design and operation of the hardware and software necessary for the use of microprocessors. Following a brief review of logic and computer fundamentals, the lectures and laboratory work cover the following microprocessor topics in depth: basic architecture; system hardware and software; interfacing considerations; and applications. The material covers the INTEL 8080 architecture with "hands-on" laboratory experiments with a microprocessor trainer.*

Thirty-nine one-hour lectures, 200-page lesson book and texts (*The BUGBOOK III: Micro Computer Interfacing - Experiments Using the MARK 80 Microcomputer, an 8080 System*, David G. Larsen, Peter R. Rony and Jonathan A. Titus, E&L Instruments, Inc., Derby, Connecticut, 1975; *INTEL 8080 Microcomputer Systems User's Manual*, INTEL Corp., Santa Clara, California, 1975; and *INTEL 8080 Assembly Language Programming Manual, 98-004C Rev. C*, INTEL Corp., Santa Clara, CA, 1976).

**For each group of 5 or more participants at a single address, the courseware will include the 60 day loan of a Microprocessor-trainer. Curcuit diagrams and parts list for the trainer are included in the lesson book.*

Eugene R. Fischer
Senior Design Engineer, Lawrence Livermore Laboratory

Michael Andrews
Assistant Professor of Electrical Engineering, CSU Faculty Adviser

SKILLS APPLIED

PERSONAL MONEY MANAGEMENT

This course uses the "how-to" approach for analyzing and directing one's financial affairs so as to protect what you have, get the most our of your present income, and increase your total income. Topics include: establishing the financial starting point; establishing financial goals, general investment planning; property, automobile, personal liability, life, health and disability insurance; housing; recordkeeping, budgeting; wills; income taxes; specific investment planning, time deposits, bonds; common stocks and mutual funds; real estate and other tax shelters.

Twelve 50-minute lectures, 220-page study guide and text (*Personal Money Management*, Thomas E. Bailard, David L. Biehl, and Ronald W. Kaiser, Science Research Associates, 1973). (Eight of the lectures in this course are presented also in Financial Planning for Retirement).

James A. Hoeven
Assistant Professor of Finance,
CSU Faculty Adviser

FINANCIAL PLANNING FOR RETIREMENT

In this course on personal money management, emphasis is placed on *pre*planning for retirement while the individual still enjoys some flexibility in his or her ability to assure the realization of their post-retirement goals of financial security and independence.The various investment and protection sources of retirement income are discussed, together with practical methods for developing financial plans tailored specifically to individual needs. Topics include: establishing the financial starting point; retirement planning; insurance principles. property, automobile, personal liability, health, disability and life insurance in retirement; wills, recordkeeping, budgeting, housing; income taxes; time deposits, bonds, annuities; common stocks, mutual funds; real estate, other tax shelters; estate transfer.

Twelve 50-minute lectures, 220-page study guide and text (*Personal Money Management*, Thomas E. Bailard, David L. Biehl, and Ronald W. Kaiser, Science Research Associates, 1973). (Eight of the lectures in this course are also presented in Personal Money Management).

Thomas E. Bailard

David L. Biehl

Ronald W. Kaiser

Bailard, Biehl & Kaiser, Inc.
Financial Advisors and
Registered Investment Counselors
Produced by the
Association for Continuing
Education (ACE)

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THE MANAGEMENT OF TECHNOLOGICAL INNOVATION

For over a decade, the Alfred P. Sloan School of Management at MIT has carried out a broad research program on the effective management of R&D, and on the commercial implementation of technological innovations. Six of its faculty report the status of that research, and its implications for R&D managers, in a recent one-day symposium captured in this lecture series.

Lecture 1: Motivating Scientists and Engineers
Professor Ralph Katz, MIT Sloan School

One of the major issues in every R&D setting. Recent research findings and contemporary views about motivation. Differences from classical perspectives and even from views popular in the 60's.

Lecture 2: User Needs and Industrial Innovation
Professor Eric Von Hippel, MIT Sloan School

How to transfer an accurate understanding of user need to the manufacturer. User dominated, manufacturer dominated, and supplier dominated modes.

Lecture 3: Technical Venture Strategies
Professor Edward B. Roberts, MIT Sloan School

Entrepreneurial alternatives: investments in small companies, joint ventures and new-venture spinoffs, and internal venture generation. Directions for enhancing new-venture results.

Lecture 4: Communication in Science and Technology
Professor Thomas J. Allen, MIT Sloan School

Technical problem-solving oriented communication at the organizational, interorganizational, and national levels. Keeping the organization abreast of current technology and the most effective techniques for transferring technology.

Lecture 5: Corporate/R&D Interface Management
Dr. William H. Gruber, MIT Sloan School

How performance of corporate/R&D divisions is determined by management policies and actions which affect the interface between R&D and the rest of the corporation. A strategy for improving performance.

Lecture 6: Innovation in Industrial Organizations
Professor James Utterback, MIT Center for Policy Alternatives, and Harvard Business School

The challenging relationship between product and production-process technologies as a central factor in determining a firm's capabilities for innovation to meet changing competitive conditions. Variables which can be manipulated by corporate management, scientists, and engineers.

Six 45-minute lectures, together with reproductions of the visual aids corresponding to each lecture (totalling 65 pages), available individually or as a set.

Videotape 7: Question-and-Answer Session

The six speakers take questions from the audience, which usually spark a discussion among the panel members. Available at no extra cost only to those renting or purchasing the complete set of six formal lectures.

TIME MANAGEMENT

This subject is directed at improving the administrative efficiency of participants through a discussion of the basic principles of effective time management in conjunction with a straight-forward, step-by-step, self-examination of what they individually do with their time. The course proceeds logically and in an orderly fashion from a determination of individual goals and specific supportive tasks to a comparison of how participants presently spend their time. Individually prepared day-by-day "To Do" lists help assess current practices with respect to the extent they contribute to the achievement of each participant's major or secondary goals. Examples of areas wherein managers are commonly deficient in the use of their time include: determination of relative priorities; delegation of responsibility and attendant authority; interruptions; staff meetings; paperwork; and procrastination.

Six 40-minute lectures and 10-page workbook.

Edwin C. Bliss
Edwin C. Bliss & Associates,
Management Consultant.
Produced by the Association
For Continuing Education (ACE)

COST SCHEDULE

Lease fees, including study guides, lesson summary books or workbooks (as appropriate) but not texts, are as follows:

Subject	Charge per Person Including Study Guide
*Artificial Intelligence	$ 99.00
Calculus Revisited (1)	155.00
Calculus Revisited (2)	122.00
Calculus Revisited (3)	100.00
Colloid & Surface Chemistry (1)	53.00
Colloid & Surface Chemistry (2)	50.00
Colloid & Surface Chemistry (3)	30.00
Colloid & Surface Chemistry (4)	51.00
Designing with Microprocessors	100.00
*Digital Signal Processing	95.00
Digital Subsystems	65.00
*Economics (1)	59.00
*Economics (2)	48.00
*Engineering Economy	60.00
Financial Planning for Retirement	56.00
*Friction, Wear and Lubrication	59.00
Fundamentals of Vacuum Technology	90.00
Introduction to Calculus	90.00
Introduction to Experimentation	46.00
*Manufacturing Quality Control	51.00
*Mechanics of Polymer Processing (1)	39.00
*Mechanics of Polymer Processing (2)	57.00
*Mechanics of Polymer Processing (3)	58.00
Microprocessor Technology and Applications	200.00
*Modern Control Theory (1)	61.00
*Modern Control Theory (2)	47.00
*Modern Control Theory (3)	97.00
*Modern Control Theory (4)	87.00
*Modern Control Theory (5)	73.00
*Network Analysis & Design in the Frequency Domain (1)	40.00
*Network Analysis & Design in the Frequency Domain (2)	60.00
Nonlinear Vibrations	63.00
Personal Money Management	56.00
Probability	196.00
Random Processes	162.00
Semiconductor Memories	75.00
Time Management	28.00

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*Color	

Videotape Equipment	Monthly Rental
½" B&W Playback Unit	$ 50.00
B&W TV Monitor	15.00
¾" Playback Unit	100.00
Color 17" Monitor	140.00

#Charges for subjects produced by MIT revised effective September 1, 1976, to reflect increased cost of study guides.